Emissions Test Report

Determination of VOC, Ethanol, and Acetaldehyde Emissions from Commercial Bakeries

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Test Report

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Radian Report Certification

This report has been reviewed by the following Radian personnel and is a true representation of the results obtained from the sampling program conducted at four commercial bakeries on behalf of the U.S. Environmental Protection Agency. The testing was conducted from May through July, 1992, except where noted, sampling and analytical methods were performed in accordance with U.S. EPA reference procedures.

APPROVAL:

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Charles R. Parrish, Project Director — Date: 9/30/92

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1.0 EXECUTIVE SUMMARY

Radian was contracted by The U.S. Environmental Protection Agency, Emissions Measurement Branch, to conduct Volatile Organic Compound (VOC) emissions testing at four commercial bakeries. Tests were conducted on a variety of bakery ovens while baking different product types. The test procedures used were the U.S. EPA Stationary Source Testing Method 25A for VOCs and Method 18 for methane, ethanol and acetaldehyde determinations. Method 25A was used to quantify total hydrocarbons (THC). Method 18 was employed to quantify methane and two of the most prevalent VOC compounds (acetaldehyde and ethanol) in the bakery emission stream. Flow rates were measured using U.S. EPA Methods 1-4 and were used to calculate emission rates of the above gas stream components.

As a part of the test program, process conditions were monitored by a separate U.S. EPA contractor. Research Triangle Institute (RTI) monitored parameters such as product type, production rates, yeast concentration, proofing time and others. This report will only present the emissions data collected by Radian and will not include any process information. A separate report completed by RTI will incorporate the emission values presented in this report with the specific bakery process information.

Two sets of emission data were calculated. The first set presents VOC as ethanol emissions calculated using the Method 25A and Method 18 methane test results. (Ethanol concentrations typically made up over 98% of the total ethanol and acetaldehyde concentrations). The second data set presents emission rates of ethanol and acetaldehyde calculated from the Method 25A and the Method 18 ethanol and acetaldehyde test results.

VOC as ethanol emissions were determined by first averaging concentrations of THC over the respective test period. Non-methane hydrocarbon concentrations were then determined by removing the methane concentration from the

THC values. VOC as ethanol concentrations were determined by dividing the non-methane hydrocarbon concentration by the ethanol carbon equivalent correction factor (CECF). The CECF was empirically determined during and following the test program. The VOC as ethanol concentrations were then multiplied by the respective stack gas flow rates to determine VOC as ethanol emission rates.

Separate emissions rates of ethanol and acetaldehyde were calculated using both the Method 25A THC and Method 18 test results. The average ethanol-to-THC ratio was multiplied times the average THC concentration to determine an average ethanol concentration and formulate a larger averaging data base within the testing time period. Average acetaldehyde concentrations were calculated in the same manner. This procedure assumed that the proportion of ethanol to THC and acetaldehyde to THC remained constant throughout the test period. This assumption did not prove always to be true; however, concentrations determined in this manner were very similar to concentrations determined by averaging the Method 18 results alone. Results from both calculation methods are presented. Ethanol and acetaldehyde emission rates were then calculated by multiplying the average concentrations by the stack gas flow rates.

1.1 VOC as Ethanol Emissions

Emission rates of VOC as ethanol are presented in Table l-l. As previously discussed, process data and production rates will not be given in this report. Product types are signified by a letter designation. Some of the test runs are not included in summary tables because these tests were only conducted on one of the two stacks coming off the ovens and; therefore, do not represent the total emissions from the ovens. A complete listing of all test results is given in Section 3.0 and in the attached Appendices.

Emissions at Site 1 ranged from 12.9 • 15.8 lbs/hr for the Bread Oven. The Site 1 Bun oven showed lower emissions of 4.3 lbs/hr. The Site 2 emissions ranged

Table 1- 1. VOC Emission Rates Assuming 100 % Ethanol EPA Bakeries, (1992)

Site Number	Product Type	Run Number	VOC as Ethanol Emission Rate (lb/hr)
Site 1			
	Bread A	Run1	12.908
	Bun B	Run2	4.290
	Bread C	Run3	12.548
	Bread A	Run4	15.771
	Bread D	Run5	14.807
Site 2			
	Bread E	Run6	11.489
	Bun F	Run7	17.750
	Bread G	Run 10	6.894
	Bread H	Run 12	40.940
Site 3			
	Bun I'	Run 13	4.739
	Bun I	Run 14	3.390
	Bread J	Run 15	12.676
	Bread K	Run 16	15.473
	Bread L	Run 17	13.038
	Bun M	Run 18	3.782
	Bread N	Run 19	7.475
	Bread K	Run 20	16.55 1
	Bread L	Run 21	15.804
Site 4			
	Bread 0	Run 22	25.43 1
	Bread P	Run 23	30.499
	Bread Q	Run 24	26.760
	Bread R	Run 25	12.678
	Bread 0	Run 26	27.687
	Bread 0	Run 27	27.179
	Bread Q	Run 28	30.068
	Bun S	Run 29 [b]	2.071
	Bun S	Run 29	2.047
	Bun T	Run 30 [b]	2.489
	Bun T	Run 30	2.629

[a] Product Names and Production Rates are not included in this report.
[b] Tests were conducted with a light steam spray injected at the front of the oven.

from 6.9 - 11.5 lbs/hr from Line 2, 17.8 lbs/hr from Line 1 and 40.9 lbs/hr from Line 3. Site 3 emissions ranged from 3.4 - 4.7 lbs/hr from the Bun oven to 7.5 - 16.5 lbs/hr for the bread oven. Site 4 emission rates varied from 12.7 - 30.5 lbs/hr for the Bread oven to 2.05 - 2.7 lbs/hr for the Bun oven.

1.2 Ethanol and Acetaldehyde Emissions

Ethanol and acetaldehyde emission rates are shown in Table l-2. Site 1 ethanol values ranged from 14.3 - 18.8 lbs/hr for the Bread oven. The corresponding acetaldehyde values ranged from 0.33 - 0.78 lbs/hr. The Site 1 Bun oven emissions of ethanol and acetaldehyde was 5.7 and 0.17 lbs/hr, respectively. The Site 2 ethanol emissions ranged from 8.1 - 14.8 lbs/hr for Line 1 oven, 22.2 lbs/hr for the Line 2 oven, and 64.6 lbs/hr for the Line 3 oven. The corresponding acetaldehyde rates were 0.24 - 0.42 lbs/hr for Line 1, 0.81 lbs/hr for Line 2, and 2.5 lbs/hr for Line 3. The Site 3 ethanol emissions ranged from 3.3 - 4.3 lbs/hr for the Bun oven and 4.9 - 16.0 lbs/hr for the Bread oven. The corresponding acetaldehyde rates were 0.21 - 0.26 lbs/hr for the Bun oven and 0.29 - 0.37 lbs/hr for the Bread oven. The Site 4 ethanol emissions were 24.8 - 53.1 lbs/hr for the Bread oven and 2.3 - 3.1 lbs/hr for the Bun oven. The corresponding acetaldehyde emissions were 0.95 - 1.4 lbs/hr for the Bread oven and 0.7 - 0.09 for the Bun oven.

1.3 Data Quality Assurance

The majority of reference method QA acceptance criteria were met during this test program. There were 10 days of testing using two THC monitoring systems (20 system days). Method 25A daily calibration drift did not exceed the criterion of $\pm 3\%$ on nineteen of the twenty system days. The Site 1, Day 1 Method 25A test data exhibited a calibration drift of 3.2%; therefore, the drift was corrected by assuming linear drift between the initial and final calibration. Over 150 Method 25A calibration error checks were performed during the test program. The majority of these calibration error checks

Table l-2. Ethanol and Acetaldehyde Emission Rates.
EPA Bakeries, (1992)

Site Number	Product Type	Run Number	Ethanol Emission Rate (lb/hr)	Acetaldehyde Emission Rate (lb/hr)
Site 1				
	Bread A	Run1	14.250	0.336
	Bun B	Run2	5.730	0.174
	Bread C	Run3	18.810	0.784
	Bread A	Run4	15.470	0.328
	Bread D	Run5	17.720	0.387
Site 2				
	Bread E	Run 6	14.820	0.417
	Bun F	Run7	22.100	0.806
	Bread G	Run 10	8.080	0.239
	Bread H	Run 12	64.580	2.509
Site 3				
	Bun I'	Run 13	4.330	0.263
	Bun I	Run 14	3.280	0.2 13
	Bread J	Run 15	9.810	0.33 1
	Bread K	Run 16	11.420	0.367
	Bread L	Run 17	12450	0.3 14
	Bun M	Run 18	3.990	0.239
	Bread N	Run 19	4.890	0.292
	Bread K	Run 20	15.980	0.3
	Bread L	Run 21	14.990	0.364
Site 4				
	Bread 0	Run 22	35.700	1.016
	Bread P	Run 23	53.080	1.371
	Bread Q	Run 24	43.280	1.368
	Bread R	Run 25	24.790	0.995
	Bread 0	Run 26	32.240	0.971
	Bread 0	Run 27	30.920	0.945
	Bread Q	Run 28	38.930	1.109
	Bun S	Run 29 [b]	2.270	0.066
	Bun S	Run 29	2.830	0.09
	Bun T	Run 30 [b]	2.630	0.066
	Bun T	Run 30	3.060	0.079

[a] Product Names and Production Rates are not included in this report.
[b] Tests were conducted with a light steam spray injected at the front of the oven.

met the Method 25A criterion of ±5% of the gas concentration. Method 25A sample bias checks, as well as 0, leak checks were also completed.

Method 18 QA/QC procedures were also followed. Initial and final calibrations were performed. Calibrations for ethanol and acetaldehyde were all completed using 3 to 5 calibration points. Multi-point calibrations were also performed on methane for low concentrations on all of the test days (< 900 ppmC). On 5 of the test days, a single point calibration was used on higher methane values. This procedure was not expected to effect data quality.

Sample bias checks were routinely conducted on the Method 18 sampling system and the majority verified acceptable non-biased sampling. However, some checks revealed sample bias caused by the loss of heat in the heated sample tubing adjacent to the gas chromatograph (GC). These data points were invalid and testing was discontinued until the problem was remedied and a successful bias check had been completed. More is discussed on this matter in Section 6.0.

1.4 Recommendations for Further Work

Further work is recommended to further characterize bakery emissions and to improve the test method. Compounds other than ethanol and acetaldehyde were not detected by the Method 18 analyses. However, trace (< 10 ppmv) levels of other compounds may be present in the bakery stream and although these compounds would not be expected to increase VOC emission rates, it would be interesting to identify them.

Another area which could be further examined is the comparison of Method 18 GC results to the Method 25A THC results. It was expected that the concentration of THC detected by the Method 25A analyzer would exceed the concentrations of the three targeted VOC compounds. However, throughout this test program, a higher concentration of compounds was determined by the GC than by the

THC monitor. Comparisons were made by first correcting concentrations of each compound determined from the GC analysis from parts per million by volume (ppmv) to ppmv as Carbon (ppmC). This was done using the previously mentioned CECF of 1.42 for ethanol, 1.23 for acetaldehyde, and 1 for methane. The sum of the the three corrected GC concentrations were then divided by the THC concentration. Typically, comparisons resulted in values of 120-140% of GC vs THC values. This error may be a result of inaccuracy in the CECF as it was applied to the sample gas matrix. Matrix effects may have somehow lowered the THC response (CECF) for ethanol as compared to the ethanol response in a dry, nitrogen calibration gas. Further work examining this Method 18 and Method 25A results comparison could be examined.

2.0 INTRODUCTION

2.1 Overview

The U.S. Environmental Protection Agency (U.S. EPA) has been requested to develop an alternative control technique (ACT) guidance document for controlling Volatile Organic Carbon (VOC) emissions from commercial baking operations. Interest has also been expressed in recalculating the AP-42[1] emission factors for bakery VOC emissions. Ethanol (C_2H_5OH) is the primary pollutant emitted from commercial bakeries.[2] Ethanol along with Carbon Dioxide (CO_2) is produced during the yeast metabolic process. Previous test data from bakeries has also revealed the presence of acetaldehyde (CH_3CHO).[2] Therefore, in conjunction with the development of an ACT document and new AP-42 emission factors, the U.S. EPA has contracted Radian Corporation to perform emissions testing of several commercial bakeries in order to gather the necessary background emissions data. This report will present the results of the U.S. EPA Bakeries test program.

The test procedures used were the U.S. EPA Stationary Source Testing Method 25A for VOCs and Method 18 for methane, ethanol and acetaldehyde determinations. Method 25A was used to quantify total hydrocarbons (THC). Method 18 was employed to quantify methane and two of the most prevalent VOC compounds (acetaldehyde and ethanol) in the bakery emission stream. By combining both procedures, the VOC emissions were fully characterized.

As a part of this data gathering phase, U.S. EPA contracted Research Triangle Institute (RTI) to monitor the baking process parameters during the emissions

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[1]Compilation of Air Pollutant Emission Factors, Section 6.13, U.S. EPA (1972).

[2]Background Documentation for AP-42, Section 6.13, Bakeries, PES for U.S. EPA (1972).

tests. Items such as dough mixing process, fermentation (proofing) time, yeast concentration, production rates and others were monitored. However, this report will only present emissions data, that will be used with the process and production rate data to develop emission factors that will be presented in a separate document.

2.2 Test Objectives

The objectives of this test program was to determine VOC emission rates as well as ethanol and acetaldehyde emission rates. The data could then be used to determine of which air pollution control techniques would be effective for the bakery industry. As discussed above, it was also desirable to correlate the emissions data with process data to update and/or verify the emission factors for commercial bakeries.

2.3 Test Methods

Because each oven had at least two stacks, concentrations of THC were continuously and simultaneously monitored on each stack using two THC continuous emissions monitoring systems (CEMS). The THC data was typically recorded on every 10 seconds a computer disk. The resulting THC data were then averaged over each period of time corresponding to a distinct segment of the process operation (i.e., 30 minute sandwich bread baking process). Methane, ethanol and acetaldehyde concentrations were measured semi-continuously using discrete analyses by a Gas Chromatograph/Flame Ionization Detector (GC/FID). One GC/FID analyzer was used for this test program. One analysis of methane, acetaldehyde, and ethanol could be completed every 10 minutes; therefore, a full oven characterization could be completed every 20 minutes (2 stacks per oven).

Method 25A and Method 18 required extracting a sample stream of the gas from the stack through a heated Teflon* tube. A portion of the sample was directed to a THC analyzer which quantified THC on a real-time basis by a Flame Ionization

Detector (FID). The THC analyzer processes unconditional gas samples; therefore, concentrations are characterized ppmv, on a wet basis. A portion of the remaining gas stream was directed to the Method 18 gas chromatograph. The GC column separated individual hydrocarbons which were quantified with the FID.

Gas flow rate was determined by using the U.S. EPA Method 2. This method called for measuring the velocity of the gas stream and by multiplying it by the stack cross-sectional area, a volumetric flow rate was determined. Method 2 also called for point location determination to be made by Method 1, CO, and 0, concentrations by Method 3 and moisture content by Method 4.

2.4 Data Reduction

As previously discussed, two sets of emission data were calculated. The first set presents VOC as ethanol emissions calculated using the Method 25A and the Method 18 methane test results. The second data set presents emission rates of ethanol and acetaldehyde calculated from the Method 25A and the Method 18 ethanol and acetaldehyde test results. The data reduction methods used are summarized in the following paragraphs.

Method 25A requires THC data to be reported in units of parts per million as Carbon (ppmC). Preliminary THC concentrations in units of ppmv as the calibration compound (i.e., propane) are multiplied by that respective compound's carbon equivalent correction factor (CECF) to correct the units to ppmC. The CECF for methane, ethane and propane are 1, 2 and 3, respectively. For example, if the Method 25A monitor was calibrated with propane, all resulting concentrations would be multiplied by the propane CECF of 3 to correct the concentration from ppmv as propane to ppmC. The THC values can be converted to ppmv of the compound of interest if 1) the specific CECF is known, and 2) the compound proportion of THC is known. For this test program, the THC monitors were calibrated with methane which has a CECF of 1, so the resulting

THC data was already in units of ppmC. However, correcting the THC concentration to VOC as ethanol concentration did require dividing the average non-methane THC concentration by the ethanol CECF. This process assumed that the non-methane hydrocarbons were made up entirely of ethanol. The resulting VOC as ethanol concentrations were then multiplied by the stack gas flow rates in order to determine VOC as ethanol emission rates.

Ethanol and acetaldehyde emissions were also calculated. Average ethanol and acetaldehyde concentrations were calculated by averaging the multiple Method 18 analytical results. However, only three Method 18 data points (per compound) were typically acquired per hour. In order to increase the number of data points in a given time period, the continuous Method 25A data was also used. An average ethanol-to-THC proportion from the above three analyses was calculated and then multiplied by the average THC value to calculate an average ethanol concentration. This method assumes that the ethanol-to-THC proportion is constant throughout the test run. Acetaldehyde calculations were performed in the same manner.

All data reduction procedures are fully explained in Section 7.0

2.5 Test Log Summary

The VOC emissions from commercial baking ovens were determined at four test sites over a 10 day test period. All tests were conducted in the summer of 1992, with Site 1 tests conducted in May, and Sites 2-4 conducted in June and July. Two ovens were tested at all sites except Site 2 where 3 ovens were tested. Tests were conducted for two days at each Site except Site 4 which were conducted over a four day period. A summary of the testing activities is presented in Table 2-1.

Table 2-1

VOC Emission Test Log
EPA Bakeries (1992)

Site	Date	Test Runs
1	May 20, 1992	1 - 3
1	May 21, 1992	4 - 5
2	June 17, 1992	6 - 11
2	June 18, 1992	12
3	June 22, 1992	13 - 17
3	June 24, 1992	18 - 21
4	June 29, 1992	22 - 23
4	June 30, 1992	24 - 25
4	July 1, 1992	26 - 28
4	July 2, 1992	29 - 30

2.6 Report Organization

A summary of the test results is presented in Section 3, a description of typical Oven Configurations and Sampling Locations is given in Section 4, and Sampling and Analytical Procedures are discussed in Section 5. Quality Assurance (QA) is presented in Section 6, and Data Reduction Procedures in Section 7. All field data and supporting calculations are included in the Appendices.

3.0 EMISSIONS RESULTS SUMMARY

This section will present the final results for the U.S. EPA Bakery emissions test program. All raw data and calculations are included in the Appendices.

3.1 Test Program Summary

Four test sites were tested using Method 25A for THC determinations and Method 18 for methane, ethane, ethanol and acetaldehyde concentrations determinations. One of the test objectives was to quantify the VOC emissions which represent only the photochemically reactive volatile organic compounds. Non-reactive compounds such as methane and ethane are subtracted from the THC concentrations for determining VOC concentrations. The VOC concentrations and emissions for this test report were calculated by assuming that all of the non-methane hydrocarbons detected by the Method 25A tests were comprised of ethanol. This was consistently observed at all four test sites as ethanol concentrations determined from the Method 18 analyses typically made up over 98% of the total ethanol and acetaldehyde concentrations (target VOCs).

In Section 3, two sets of emissions data are given. The first data set presents emissions of VOC as ethanol as discussed above. The VOC concentration as ethanol was calculated by dividing the non-methane hydrocarbon concentration in units of ppmC by the ethanol THC Carbon Equivalent Correction Factor. The CECF was determined by observing the response of the THC analyzer to known concentrations of ethanol. The second data set presents emissions of ethanol and acetaldehyde emissions determined from the Method 18 ethanol and acetaldehyde results and the THC results. Emissions were calculated by multiplying the respective stack gas concentrations by the stack gas flow rate by the methods discussed above. All calculations are shown in Section 7.0.

Methane concentrations were higher than expected during the test program which did not allow for the resolution of the ethane GC peak at three of the test sites. However, ethane concentrations were expected to be fairly low and so the error in determining VOC is expected to be minimal.

The emissions of both direct- and indirect-fired ovens were measured (see Section 4.1.2) while baking a variety of bakery products. Production rate is the most critical factor related to the quantity of bakery VOC emissions. However, as discussed in the previous section, no product information or process data will be given in this report. The general category of ovens tested will be identified, differentiating direct-fired from indirect-fired and bread from bun ovens.

Thirty test runs were conducted for a typical sample period of 1 hour. Some of the runs were shorter than an hour due to the stoppage of the product being baked. Emissions was measured from only a single product at one time. Time periods when the ovens were in transient conditions, either from start up/shut down occurrences or from product changes or gaps in the product feed, were not included in the reported data base. However, all of the field data is included in the Appendices.

A general description of the commercial baking process and bakery ovens along with the types of ovens tested at each test site is given in Section 4. A total of two or three stacks were tested simultaneously from each oven. The total oven emissions were calculated by totaling the emissions from each of the stacks. Emissions from comfort hood stacks (see Figure 4-1) were not originally intended to be tested. However, it was noticed during the Site 2 test program that these emissions represented a significant portion of the total oven emission rates and from that point on, comfort hood emissions were tested. The Site 1 bread oven did have a comfort hood which was not tested during this test program. Therefore, the total bread oven emissions for that site may be somewhat lower than actual.

3.2 Site 1 Test Results

A large bread oven and a smaller bun oven were tested at the Site 1 commercial bakery. The bread oven was a direct-fired oven which had three vent stacks arranged longitudinally. The middle stack was used only during oven purging (start-up) and was capped off with a small metal drum during the emissions tests. The absence of flow at this stack was confirmed using a sensitive hot-wire anemometer (O-600 fpm scale). After the test was completed, it was later discovered that there was a comfort hood located at the oven bread exit. Gases from the hood were directed up through a vent stack on the roof. However, this stack was not tested and the resulting total oven emissions may be biased low.

32.1 Site 1 Test Log

Emissions tests were conducted on May 20 and 21, 1992. All tests were observed by an U.S. EPA/EMB observer. Five test runs were conducted on two ovens. On Day 1, two types of products were tested (Runs 1 & 2) and three runs on one type of product were conducted on Day 2. Table 3-1 presents a summary of the Site 1 sampling activities.

3.2.2 Site 1 VOC as Ethanol Emissions Test Results

Table 3-2 presents the VOC as ethanol test results. The table presents THC concentrations (including methane) as well as VOC concentrations derived by removing the methane concentrations from the THC values (ppmC/wet). Concentrations of VOCs are also given in ppmv as ethanol, calculated as discussed above. Emission rates from each stack are calculated from the VOC as ethanol concentrations. The total oven VOC emissions are then calculated by totaling the emissions from both vent stacks.

Table 3-1

Site 1 Bakery VOC Emissions Test Log EPA Bakeries (1992)

Run	Date	Sampling Time	Product	Number of GC injections	
				Front	Rear
1	5/20/92	11:58-13:16	Bread A	3	3
2	5/20/92	14:30-15:31	Bun B	3	3
3	5/21/92	07:37-09:14	Bread C	3	4
4	5/21/92	10:01-10:24	Bread A	1	1
5	5/21/92	21:03-22:41	Bread D	4	3

Table 3–2. VOC Emissions Assuming 100 % Ethanol
EPA Bakeries, Site 1 (1992)

Run	Run 1		Run 2		Run 3		Run 4		Run 5	
Stack Location	**Front**	**Rear**	**Front**	**Rear**	**Front**	**Rear**	**Front**	**Rear**	**Front**	**Rear**
THC Conc. (ppmC/wet)	1015.3	2822.8	2687.6	704.8	1035.4	3554.5	1125.8	3097.3	1075.2	3241.9
Methane Concentrations										
Methane Conc. (ppmv/wet) [1]	977	658.7	2006	212.1	779	1542.5	389	841	820.3	819
Methane/THC Ratio	0.859	0.231	0.737	0.276	0.626	0.451	0.332	0.263	0.729	0.257
Methane Conc. (ppmC/wet) [2]	872.14	652.06	1980.7	194.52	648.16	1603.0	373.76	814.58	783.82	833.168
VOC Emissions										
VOC Conc. (ppmC/wet) [3]	143.2	2170.7	706.8	510.3	387.2	1951.4	752.0	2282.7	291.4	2408.7
VOC Conc. as Ethanol (ppmv/wet) [4]	100.8	1528.7	497.8	359.3	272.7	1374.2	529.6	1607.5	205.2	1696.3
VOC Emission Rate as Ethanol (lb/hr) [4]	0.52	12.38	2.82	1.47	1.41	11.13	2.75	13.02	1.06	13.74
Total VOC Emissions as Ethanol (lbs/hr) [4]	12.908 [a]		4.290		12.548		15.771 [a]		14.807	

1 Values calculated from average methane concentrations determined from multiple GC analyses.

-- Values calculated from average Methane to THC ratios (CH4/THC) incorporating both GC and THC analyses:

2 Methane Conc. = Avg ($CH4_i / THC_i$) * (Avg THC)

3 VOC Conc. = Avg ($1 - CH4_i / THC_i$) * (Avg THC)

4 VOC Conc. as Ethanol = (VOC Conc) / 1.42 VOC Emissions as Ethanol = (VOC Conc. as Ethanol) * Flow; where 1.42 is the empirically derived carbon equivalent correction factor

a Ethanol GC Results are suspect. However, these values do not incorporate the ethanol GC results (methane only)

Runs 1 and 3-5 were conducted on the Bread oven. The total emissions for these runs may be biased slightly low as the comfort hood stack was not tested.

3.2.3 Site 1 Ethanol and Acetaldehyde Emission Test Results

Table 3-3 presents the emission rates and concentrations of ethanol and acetaldehyde in two ways. The first method reports the ethanol concentration determined by averaging the results of the Method 18 analyses. The second method multiplies the average ethanol-to-THC ratio by the average THC value to determine average ethanol concentrations. The second method assumes a constant ethanol-to-THC proportion and by using the continuous THC data base (THC values every minute), incorporates a much larger data base for averaging. Ethanol emissions are calculated from concentrations determined by both methods. However, the total oven emissions were determined from concentrations using the THC data. Acetaldehyde values were calculated similarly. All data reduction procedures is given in Section 7.

3.2.4 Site 1 Method 25A and Method 18 Analytical Results

This section presents the results from the Method 18 analyses. The Method 25A THC concentrations are given for same time period that the GC injections were made. Typically, three injections were made during a test run at a specific sample location. The concentrations were then averaged. Some GC injections were made that did not fall into the test run time-frame. Results from these analyses are presented in the tables but are not included in the averages. Ethanol-to-THC and acetaldehyde-to-THC ratios were calculated for each injection as well. The ethanol and acetaldehyde values were not corrected to ppmC for this calculation; therefore, these values cannot be considered volumetric proportions of the THC stream. Their purpose was to be multiplied by the average THC value to calculate average methane, ethanol,

Table 3-3. Ethanol and Acetaldehyde Emissions Test Results EPA Bakeries, Site 1 (1992)

Run	Run 1		Run 2		Run 3		Run 4		Run 5	
Stack Location	Front	Rear	Front	Rear	Front	Rear	Front	Rear	Front	Rear
THC Conc. (ppmC/wet)	1015.3	2822.8	2687.6	704.8	1035.4	3554.5	1125.8	3097.3	1075.2	3241.9
Ethanol Emissions										
Ethanol Conc. (ppmv/wet) [1]	464	S	677	503.7	270.3	2140	S	S	370	1930
Ethanol Conc. (ppmv/wet) [2]	413.2	1494.4 [a]	671.9	469.4	223.6	2178.9	525.9 [a]	1572.1 [a]	352.7	1961.3
Ethanol/THC Ratio	0.407	S	0.25	0.666	0.216	0.613	S	S	0.328	0.605
Ethanol Emission Rate (lb/hr) [1]	2.41	S	3.83	2.07	1.40	17.34	S	S	1.92	15.64
Ethanol Emission Rate (lb/hr) [2]	2.14	12.11	3.80	1.93	1.16	17.65	2.73	12.74	1.83	15.89
Total Ethanol Emission Rate (lbs/hr) [2]	14.25 [a]		5.73		18.81		15.47 [a]		17.72	
Acetaldehyde Emissions										
Acetaldehyde Conc. (ppmv/wet) [1]	8.78	39.60	29.40	4.59	14.70	99.70	4.27	40.90	11.80	45.10
Acetaldehyde Conc. (ppmv/wet) [2]	7.82	38.39	29.03	4.37	12.94	92.77	4.17	39.65	11.18	44.09
Acetaldehyde/THC Ratio	0.77	1.36	1.08	0.62	1.25	2.61	0.37	1.28	1.04	1.36
Acetaldehyde Emission Rate (lb/hr) [1]	0.044	0.307	0.159	0.018	0.073	0.773	0.02 1	0.317	0.059	0.349
Acetaldehyde Emission Rate (lb/hr) [2]	0.039	0.298	0.157	0.017	0.064	0.719	0.02 1	0.307	0.055	0.342
Total Acetaldehyde Emission Rate (lbs/hr) [2]	0.336		0.174		0.783		0.328		0.397	

[1] Values calculated from average concentrations determined from multiple GC analyses.

[2] Values calculated from average Ethanol/THC and Acetaldehyde/THC ratios (ETOH/THC and AA/THC) incorporating both GC and THC analyses: ETOH Conc. = Avg (ETOH i /THC i) * (Avg THC): ETOH Emissions = (Avg ETOH Conc.) * Flow

AA Conc. = Avg (AA $_i$ /THC $_i$) * (Avg THC): AA Emissions = (Avg AA Conc.) * Flow

S = Suspect Ethanol GC Analysis

[a] Due to the invalidated ethanol GC results, the value was calculated as folows: {(VOC Conc.) – (A.A. Conc * 1.23)) / 1.42 where 1.23 and 1.42 are the carbon equivalent correction factors for A.A.:CH4 and Ethanok CH4, respectively. Emissions calculated as shown above.

and acetaldehyde concentrations. This allowed ethanol and acetaldehyde concentrations to be calculated without incorporating the additional methane analysis.

Finally, a comparison of the total concentration of the three target compounds detected by the GC was made with the THC values for each discrete injection. This parameter is not required by the reference method QA procedures, but it was originally thought to be an indication what proportion of THC the three target compounds represented. It was expected that the sum of the GC concentrations would be somewhat lower that the total THC concentration taking into account trace concentrations of organics in the gas stream that were not detected by the GC analyses. However, this comparison may not be sufficiently accurate. The average ratio is calculated as follows:

$$\overline{\left(\frac{GC}{THC}\right)} = \frac{\sum_{i=1}^{N} \frac{GC_i}{THC_i}}{N} \times 100$$

where:

THC, = THC concentrations determined from the Method 25A monitor at the same time as the GC injection (ppmC)

N = Number of GC injectors in the time period.

The units from the GC analyses have to be corrected to the same units as the THC concentrations (ppmC) as follows:

$$GC_i = \left(\frac{[ETOH]_i}{1.42} + \frac{[AA]_i}{1.23} + [CH_4]_i \right)$$

where:

$[ETOH]_i$	=	Ethanol concentration determined from a single GC analysis (ppmv/wet)
1.42	=	Ethanol THC Carbon Equivalent Correction Factor (empirically derived)
$[AA]_i$	=	Acetaldehyde concentration determined from a single GC analysis (ppmv/wet)
1.23	=	Acetaldehyde THC Carbon Equivalent Correction Factor (empirically derived)
$[CH_4]_i$	=	Methane concentration determined from a single GC analysis (ppmv/wet). NOTE: The methane CECF is 1.0.

The CECFs used for this test program were determined by challenging the THC analyzer with known, certified concentrations of ethanol and acetaldehyde and recording the response. For example, if a 200 ppmv ethanol gas standard responded as 300 ppmC THC, then the ethanol CECF was 1.5. The CECFs were determined over the entire range of concentrations observed during the test program. It is difficult to predict whether the THC analyzer responded to the ethanol in the bakery sample gas matrix the same (quantitatively) as to ethanol in a clean, dry calibration gas. Both sample gas moisture levels and 0, levels were different than the calibration gas matrix (dry, N_2 balance). The unexpected high GC/THC ratios (> 100%) may have resulted from a variability in the actual sample CECF.

Tables 3-4 and 3-5 present the Method 18 and 25A test results for the Site 1 front and rear stacks , respectively. The test results have been discussed in detail in the previous sections; however, the following tables can provide an additional perspective into the data.

Table 3-4. Method 25A and Method 18 Emissions Tests Results, Front Stack, EPA Bakeries, Site 1 (1992).

FRONT/OVEN STACK									
RUN	TIME	METHOD	METHOD 18 GC RESULTS			GC/THC	THC PROPORTIONS [c]		
		25A THC RESULTS' (ppmC/wet)	ETHANOL (ppmv/wet)	METHANE (ppmv/wet)	ACET-ALDEHYDE (ppmv/wet)	RATIO [b] (%)	ETH/THC RATIO	CH4/THC RATIO	AA/THC RATIO
1	11:55:54	1136.9	212	1181	11.7	131.4	0.186	1.037	0.010
1	12:33:55	1141.7	868	765	8.24	175.9	0.760	0.670	0.007
1	12:56:06	1132.3	312.1	985	6.43	126.8	0.276	0.870	0.006
1	AVG	1015.3	464.0	977.0	8.8	144.7	0.407	0.859	0.008
2	14:31:59	2834.1	581	2117	29	105.1	0.205	0.747	0.010
2	14:50:57	2669.1	858	2070	32.7	124.7	0.321	0.776	0.012
2	15:13:59	2655.1	592	1831	26.4	101.8	0.223	0.690	0.010
2	AVG	2687.6	877.0	2006.0	29.4	110.5	0.250	0.737	0.011
3	07:36:50	1211.3	236	760	8.66	91.3	0.195	0.627	0.007
3	07:57:48	1526.2	328	663	12.1	89.3	0.215	0.579	0.008
3	08:17:47	1032.5	247	694	23	103.9	0.239	0.672	0.022
3	AVG	1035.4	270.3	779.0	14.7	94.9	0.218	0.626	0.013
4	10:04:19	1170.4	122	389	4.27	48.5	0.104	0.332	0.004
4	AVG	1125.8	122	389	4.27	46.4679	0.104	0.332	0.004,
5	21:03:59	1117.1	237	914	11.2	113.2	0.212	0.818	0.010
5	21:27:01	1091.9	368	730	11.4	116.0	0.337	0.669	0.010
5	22:15:00	1162.2	389	761	11.7	114.2	0.335	0.655	0.010
5	22:25:59	1133.0	353	876	12.2	122.9	0.312	0.773	0.011
5	AVG	1075.2	338.8	820.5	fl.8	116.6	0.299	0.729	0.010

[a] THC averages calculated from the full CEM data base (not just the above entries)

[b] GC/THC RATIO = (ETOH/1.42+AA/1.23+CH4)/THC * 100 where: 1.42 = Ethanol CECF
1.23 = Acetaldehyde CECF

[c] THC proportions were calculated as:ETH/THC = ppmv ethanol/ppmC THC, CH4/THC = ppmv CH4/ pmC THC, AA/THC = ppmv acetaldehyde/ ppmC THC

Table 3-5. Method 25A and Method 18 Emissions Tests Results, Rear Stack, EPA Bakeries, Site 1 (1992).

REAR/BURNER STACK									
RUN	TIME	METHOD 25A THC RESULTS[a] (ppmC/wet)	METHOD 18 GC RESULTS			GC/THC RATIO[b] (%)	THC PROPORTIONS[c]		
			ETHANOL (ppmv/wet)	METHANE (ppmv/wet)	ACET-ALDEHYDE (ppmv/wet)		ETH/THC RATIO	CH4/THC RATIO	AA/THC RATIO
1	12:05:57	3185.8	14100 S	601.0	49.9	849.3	4.426	0.189	0.016
1	12:44:54	2799.6	5850 S	793.0	29.2	328.3	2.090	0.263	0.010
1	13:06:05	2640.7	14600 S	582.0	39.0	809.0	5.529	0.220	0.015
1	**AVG**	2022.8	**S**	858.7	**39.4**	**594.9**	**4.015**	**0.231**	**0.014**
2	14:41:58	818.6	674.0	255.0	5.5	148.9	0.823	0.312	0.007
2	15:03:00	574.0	235.0	65.4	3.2	70.2	0.409	0.114	0.005
2	15:24:58	764.4	602.0	316.0	5.2	150.1	0.767	0.403	0.007
2	**AVG**	**704.8**	503.7	212.11	4.8	**123.1**	**0.887**	**0.278**	**0.006**
	07:46:49	3125.9	1940.0	1540	46.2	139.2	0.621	0.493	0.015
3	08:07:47	3947.2	2620.0	1480	225	136.8	0.864	0.375	0.057
3	08:28:46	2959.8	1660.0	1530	27.1	132.5	0.561	0.517	0.009
3	09:01:43	3867.9	2340.0	1620	47	129.3	0.605	0.419	0.012
3	**AVG**	**3554.5**	**2140.0**	**1542.5**	66.3	**134.9**	0.613	0.451	0.023
4	10:14:35	3192.4	7930 S	841	40.9	380.6	2.484	0.263	0.013
4	**AVG**	**3097.3**	**S**	**841**	**40.9**	**380.6**	**2.484**	**0.263**	**0.013**
NA	21:36:01	3271.3	3730.0	1070	43.6	196.3	1.140	0.327	0.015
NA	21:55:59	3528.2	5650.0	1040	55.9	258.8	1.601	0.295	0.016
5	21:15:02	3192.2	1930.0	819	40.3	113.1	0.605	0.257	0.01:
5	**AVG**	3241.0	1990.0	819.0	**40.3**	**113.1**	**0.605**	0.257	**0.013**

[a] THC averages calculated from the full CEM data base (not just the above entries)

[b] GC/THC RATIO = (ETOH/1.42+AA/1.23+CH4)/THC • 100 where: 1.42 = Ethanol CECF
1.23 = Acetaldehyde CECF

[c] THC proportions were calculated as: ETH/THC = ppmv ethanol/ppmC THC, CH4/THC = ppmv CH4/ pmC THC,
AA/THC = ppmv acetaldehyde/ ppmC THC

S = Suspect, data invalidated.

NA = Not Applicable. Values were not incorporated into the averages.

Four tests (Runs 1, 3-5) were conducted on the bread oven. Run 4 was a duplicate of Run 1 and was conducted for only 23 minutes. The ethanol-to-THC ratios for the front bread stack, were fairly consistent at approximately 0.20. Ratios for Run 1 ranged from 0.19 to 0.76. The ethanol-to-THC proportion for the rear stacks was approximately 0.60. Ethanol from Runs 1 and 4 (same product) appeared suspect, with ethanol-to-THC ratios of 2.0 to 5.5 (5850 ▪ 14,100 ppmv ethanol vs 2,800- 3,200 ppmC THC, GC/THC values of 300 to 800 percent). The ethanol results from these two test runs were not used to calculate either VOC as ethanol emissions or ethanol emission rates.

The Run 2 results from the Site 1 Bun oven, showed consistent ethanol-to-THC proportions of about 0.25 for the front stack while the rear stack ranged from 0.40 ▪ 0.80. The GC-to-THC ratios for this run were 105 and 108% for the front and rear Bun oven stack, respectively.

The Site 1 Method 25A and Method 18 results are presented graphically for Runs 1-5 in Figures 3-l through 3-5, respectively. Method 18 concentrations have been corrected to ppmC for these plots.

3.2.5 Stack Gas Flow Rates

Table 3-6 presents the stack gas flow rates and the temperatures used for determining emission rates. A single Method 2 flow rate traverse and a Method 4 moisture determination were completed on the four stacks (2/bread oven & 2/bun oven). Flows were not corrected to a dry basis since Method 25A and 18 concentrations were determined on a wet basis and emissions calculations required both flows and concentrations be consistently on the same basis (wet or dry). Moisture content values are included in Appendix A.7.

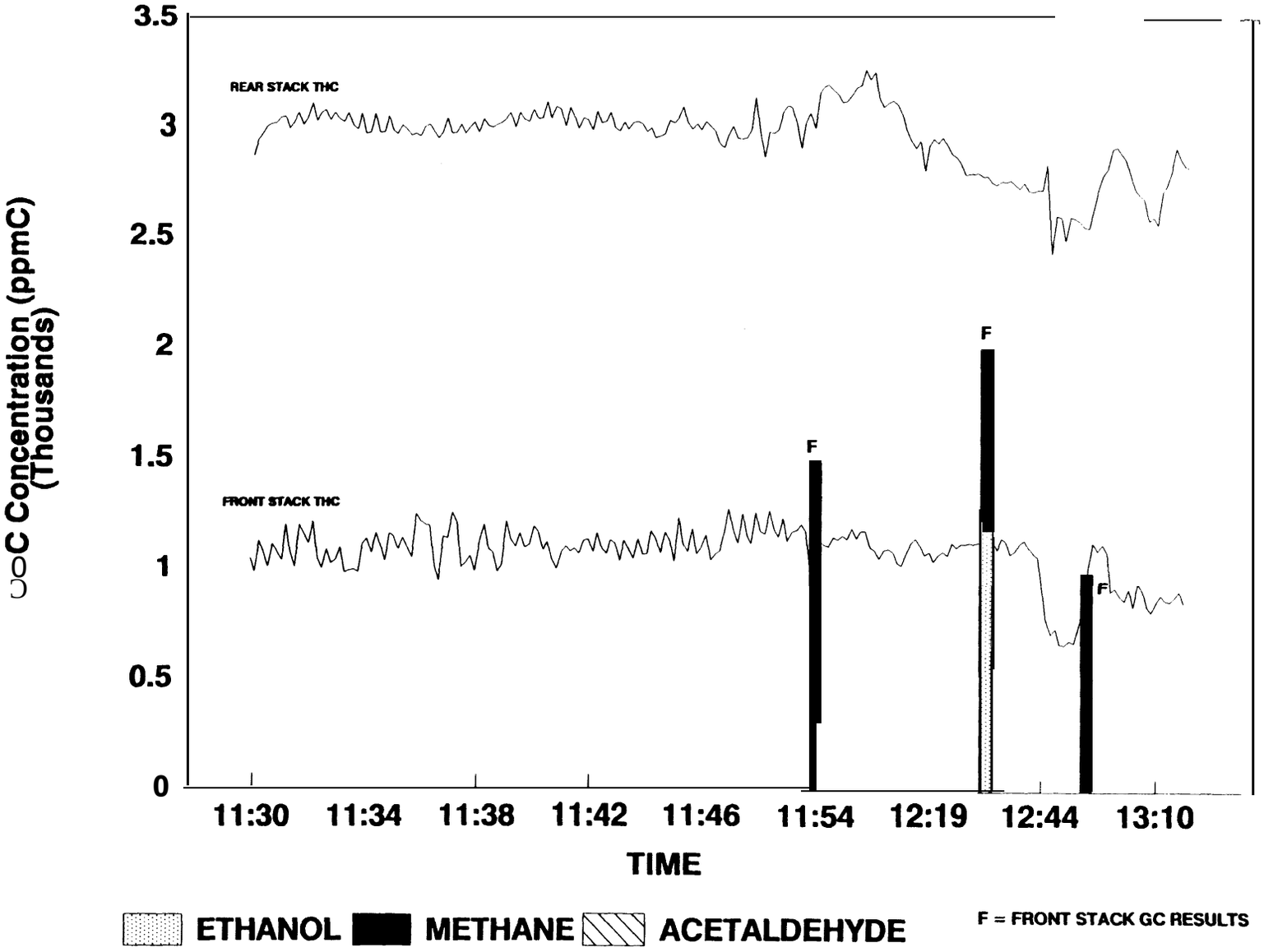

Figure 3-1. Run 1 Method 25A and Method 18 Results (adjusted to ppmC) .

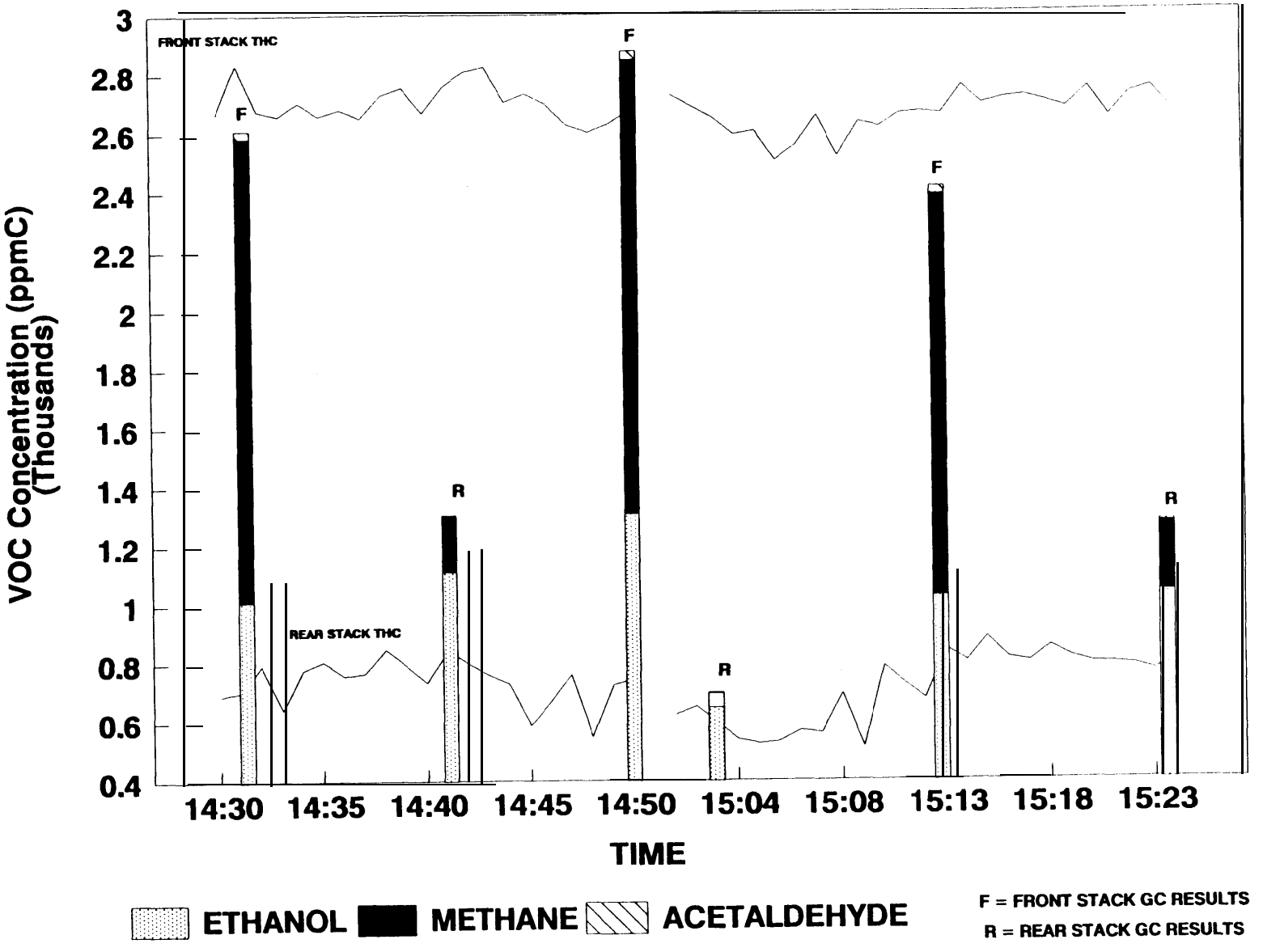

Figure 3-2. Run 2 Method 25A and Method 18 Results (adjusted to ppmC) .

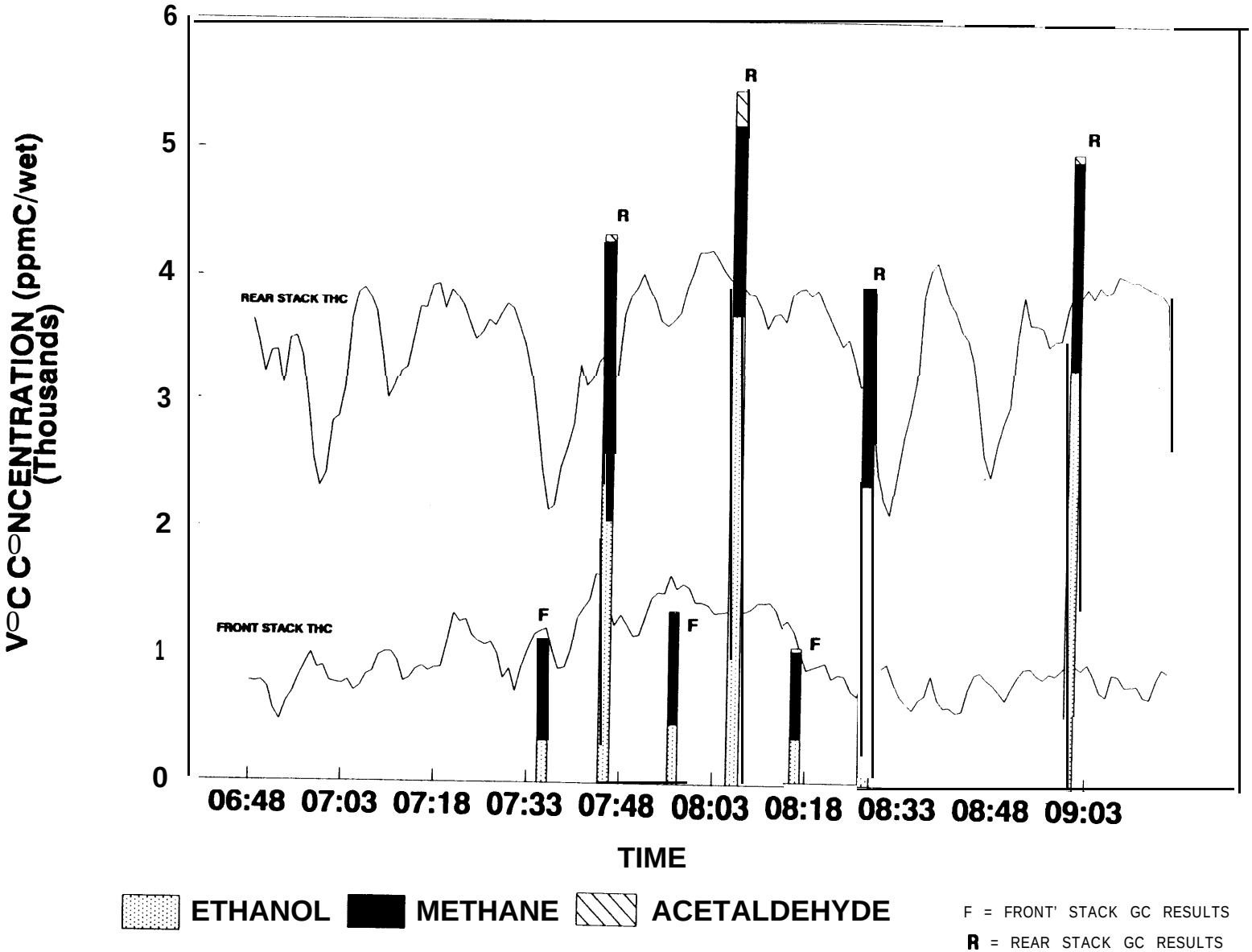

Figure 3-3. Run 3 Method 25A and Method 18 Results (adjusted to ppmC) .

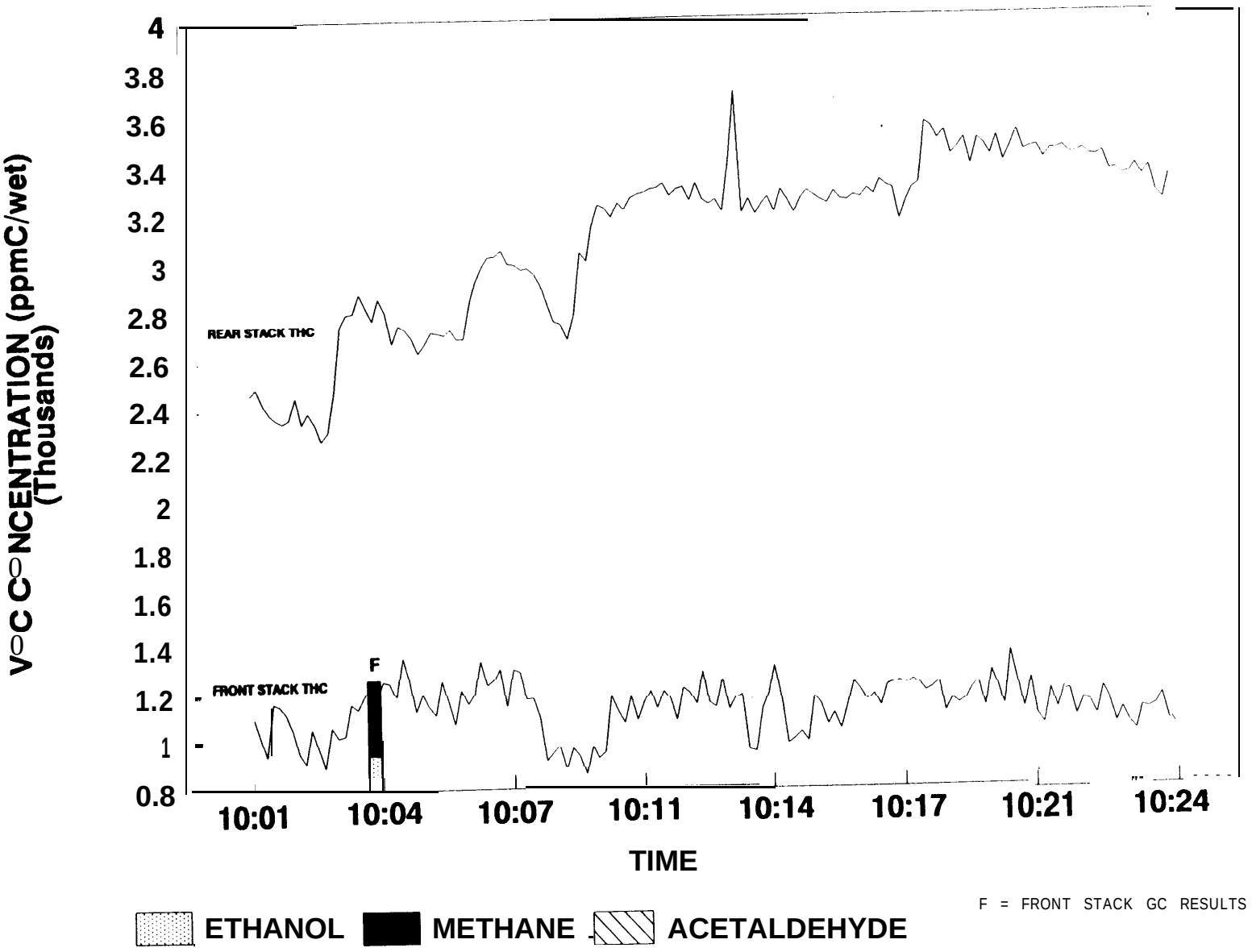

Figure 3-4. Run 4 Method 25A and Method 18 Results (adjusted to ppmC) .

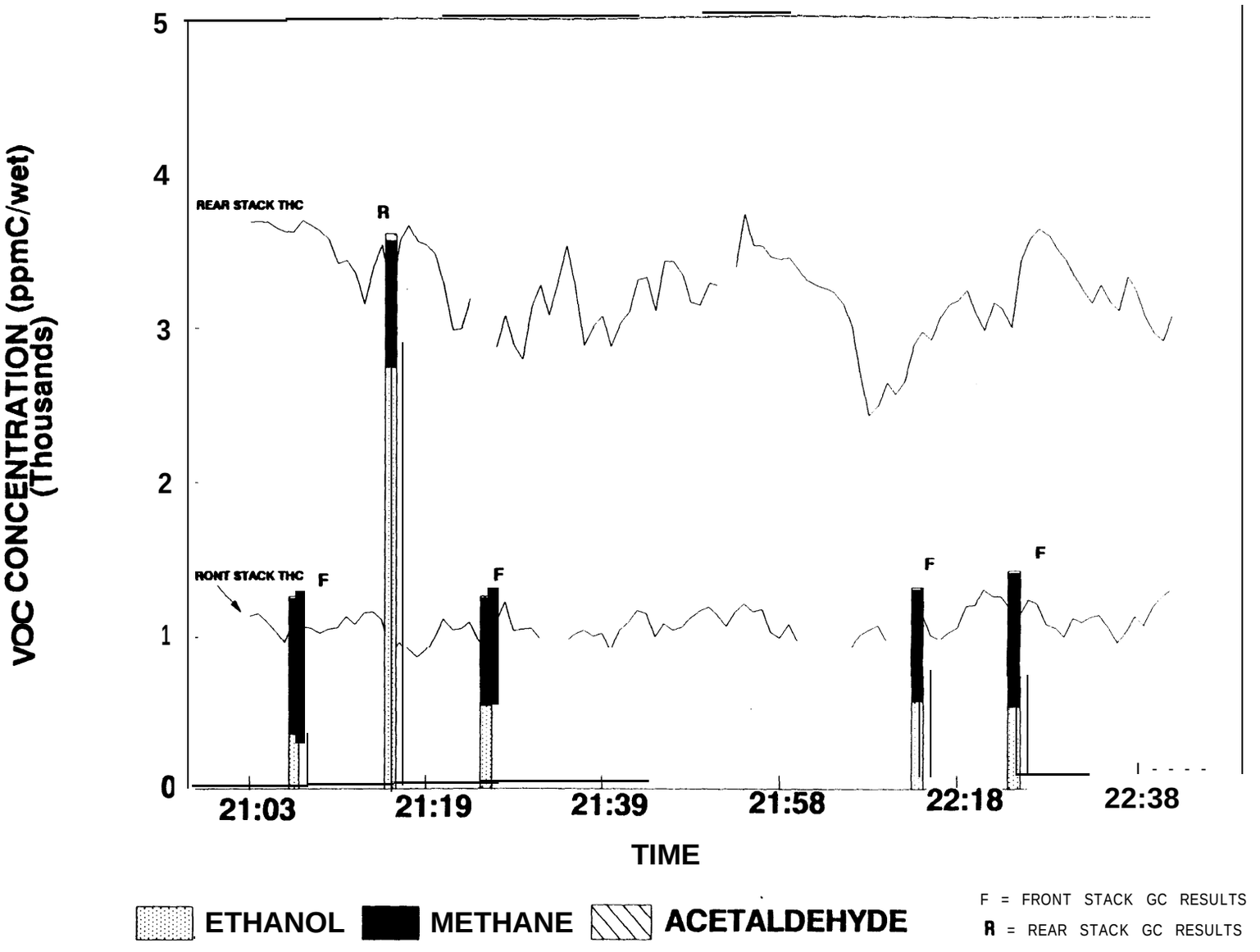

Figure 3-5. Run 5 Method 25A and Method 18 Results (adjusted to ppmC) .

Table 3-6. Summary of Flue Gas Sampling Parameters
EPA Bakeries, Site 1 (1992)

Run Number	Location	Stack Gas Temperature (deg F)	Barometric Pressure (in. Hg)	stack Gas Static Pressure (in H2O)	Volumetric Flow Rate (acfm)	Volumetric Flow Rate (scfm)
Run 1	Front	259	29.9	-0.03	988	713
	Rear	362	29.9	-0.03	1,762	1,119
Run2	Front	286	29.9	-0.04	1,117	781
	Rear	193	29.9	-0.02	709	567
Run 3	Front	259	29.9	-0.03	988	713;
	Rear	362	29.9	-0.03	1,762	1,119
Run 4	Front	259	29.9	-0.03	988	713
	Rear	362	29.9	-0.03	1,762	1,119
Run 5	Front	259	29.9	-0.03	988	713
	Rear	362	29.9	-0.03	1,762	1,119

Flow rates ranged from 700 - 1100 standard cubic feet per minute (scfm) on the bread oven and 600-800 scfm on the bun oven. On each oven, one of the two stacks consistently had higher temperatures and higher VOC emission rates. The rear stack bread oven was the higher of the two bread oven stacks and the front stack on the bun oven was hotter and had higher VOCs of the two bun oven stacks. Specific process data is not included in this report however, these occurrences can probably be explained by burner type or burner maintenance status for the ovens.

3.3 Site 2 Test Results

A small bun oven, a small bread oven and a larger bread oven were tested at Site 2. These ovens were identified as Lines 1, 2, and 3, respectively. The first two ovens were tested with the CEM trailer location; however, the trailer had to be moved test the third oven (Bread, Line 3).

All of the ovens tested at Site 2 had comfort hoods which were exhausted by an axial fan roof ventilator. There were no duct work following the fan; therefore, the U.S. EPA Method 1 specifications were not met. Flow measurements had to be taken directly at or after the fan since the gas was vented to atmosphere (see Figure 4-6). Therefore, the resulting emission rates may have a higher degree of measurement error.

The oven on Line 1 predominantly bakes buns. There was a front and rear stack as well as a comfort hood vent. The comfort hood fan was not operating during the test and may not have operated for sometime. Gas flow was induced strictly by natural drafting of the hot gases at velocities of SO-300 fpm and at temperatures of approximately 150°F.

The Line 2 was an indirect-fired unit. The oven gases were vented from a stack located in the front of the oven with the burner stack in the rear. As with the Bun

oven, there was a comfort hood which was vented by a axial fan roof ventilator. There was no gas ductwork following the fan; therefore, the flow measurement could not be made at a location in accordance with U.S. EPA Method 1 procedures. Flows were estimated using both velocity pressure measurements and hot-wire anemometer measurements.

The Line 3 bread oven was a direct-fired unit with two stacks located approximately 90 feet apart and a comfort hood. The front stack and comfort hood were alternately sampled using the same sample system and THC monitor.

3.3.1 Site 2 Test Log

Seven emissions test runs (Runs 6-12) were conducted on June 17 and 18, 1992. Runs 6 and 10 were conducted on the Line 2 Bread oven, Run 7 was conducted on the Line 1 Bun oven, Runs 8,9 and 11 were conducted on the Line 1 and 2 comfort hoods, and Run 12 was conducted on the Line 3 bread oven stack. Five of the seven test runs were conducted on two ovens. Table 3-7 presents a summary of the Site 2 sampling activities.

3.3.2 Site 2 VOC as Ethanol Emissions Test Results

Table 3-8 presents the VOC as ethanol test results.

3.3.3 Site 2 Ethanol and Acetaldehyde Emission Test Results

Table 3-9 presents the emission rates of ethanol and acetaldehyde.

Table 3-7

Site 2 Bakery VOC Emissions Test Log EPA Bakeries (1992)

Run	Date	Sampling Time	Oven & Product Designation	Number of GC Injections	
				Front	Rear
6	6/17/92	11:33-13:00	Bread E	3	0
7	6/17/92	15: 17-16: 14	Bun F	4	3
8	6/17/92	16:22-16:26	Bun Comfort Hood Only	1	NA[a]
9	6/17/92	16:40-16:43	Bread Comfort Hood Only	0	NA
10	6/17/92	16:47-17:47	Bread G	3	4
11	6/17/92	18:36-18:44	Bun/Bread Comfort Hood Only	0	0
12	6/18/92	15:22-19:13	Bread H	5	10

[a]NA = Runs 8 and 9 were conducted on a single stack (comfort hood) for each run.

Table 3-8. VOC Emissions Assuming 100 % Ethanol
EPA Bakeries, Site 2 (1992)

Run	Run 6		Ron 7		Run 8	Run 9	Run 10	
Stack Location	**Front**	**Burner**	**Front**	**Rear**	comfort [e]	**Comfort** [e]	Front	**Burner**
THC Conc. (ppmC/wet)	16375	52.7	1724.3	1398.3	1157.5	120.9	669.8	48.8
Methane Concentrations								
Methane Conc. (ppmv/wet) [1]	3.8	NO GC	33.1	28.5	13.2	NO GC	13.2	13.2
Methane/THC Ratio	0.003	NO GC	0.019	0.019	0.011	NO GC	0.004	0.047
Methane Conc. (ppmC/wet) [2]	4.913	0 [d]	32.762	26.568	12.733	0 [d]	2.679	2.294
VOC Emissions								
VOC Conc. (ppmC/wet) [3]	1632.6	52.7	1691.5	1371.7	1144.8	120.9	667.1	46.5
VOC Conc. as Ethanol (ppmv/wet) [4]	1149.7	37.1 d	1191.2	966.0	806.2	85.1 d	469.8	32.8
VOC Emission Rate as Ethanol (lb/hr) [4]	7.73	0.20	6.96	8.71	2.16	3.19	3.16	0.17
Total VOC Emissions as Ethanol (lbs/hr) [4]	11.489 [b]		17.750 [c]		2.156	3.195	6.894 [b]	

1 Values calculated from average methane concentrations determined from multiple GC analyses.

- - Values calculated from average Methane to THC ratios (CH4/THC) incorporating both GC and THC analyses:

2 Met bane Conc. = Avg (CH4 i /THC i) * (Avg THC)

3 VOC Conc. = Avg (1 − $CH4_i/THC_i$) * (Avg THC)

4 VOC Conc. as Ethanol = (VOC Conc) / 1.42 VOC Emissions as Ethanol = (VOC Conc. as Ethanol) • Flow; where 1.42 is the empirically derived carbon equivalent correction factor

a Assumed value taken from similar location.

b Incorporated average Line 2 C.H. emissions of 3.56 ethanol Runs 9 & 11

c Incorporated average Line 1 C.H. emissions of 2.08 ethanol from Runs 8 & 11

d GC analyses was not performed for this location therefore the VOC concentration was assumed to be 100 % of the THC conc.

e Runs 8 & 9 were conducted on the Line 1 and Line 2 Comfort Hood stacks only.

Table 3-8. VOC Emissions Assuming 100 % Ethanol (cont.)
EPA Bakeries, Site 2 (1992)

Run	Run 11A	Run 11B	Run 12		
Stack Location	**L1 C.H.** [b]	**L2 C.H.** [b]	**Front**	**Comfort**	**Rear**
THC Conc. (ppmC/wet)	1067.6	148.7	4114.2	638.9	2992.1
Methane Concentrations					
Methane Conc. (ppmv/wet) [1]	NO GC	NO GC	1193	NO GC	1776.5
Methane/THC Ratio	NO GC	NO GC	0.402	NO GC	0.542
Methane Conc. (ppmC/wet) [2]	0 [a]	0 [a]	1653.9	0 [a]	1621.7
VOC Emissions					
VOC Conc. (ppmC/wet) [3]	1068 [a]	148.7 [a]	2460.3	638.9 [a]	1370.4
VOC Conc. as Ethanol (ppmv/wet) [4]	751.8	104.7	1732.6	449.9	965.1
VOC Emission Rate as Ethanol (lb/hr) [4]	2.0	3.93	25.17	2.26	13.51
Total VOC Emissions as Ethanol (lbs/hr) [4]	2.011	3.929		40.94	

1 Values calculated from average methane concentrations determined from multiple GC analyses.

- - Values calculated from average Methane to THC ratios (CH4/THC) incorporating both GC and THC analyses:

2 Methane Conc. = Avg (CH4 i /THC i) • (Avg THC)

3 VOC Conc. = Avg (1 - $CH4_i/THC_i$) • (Avg THC)

4 VOC Conc. as Ethanol = (VOC Conc) / 1.42 VOC Emissions as Ethanol = (VOC Conc. as Ethanol) * Flow; where 1.42 is the empirically derived carbon equivalent correction factor

a GC analyses was not performed for this location; therefore, the VOC concentration was assumed to be 100 % of the THC conc.

b Tests were done on the Line 1 and line 2 Comfort Hood stacks.

Table 3-9. Ethanol and Acetaldehyde Emissions Test Results
EPA Bakeries, Sitk 2 (1992)

Run	Rua 6		Run 7		Run 8 [d]	Run 9 [d]	Run 10	
Stack Location	Front	Burner	Front	Rear	Comfort	Comfort	Front	Burner
THC Conc. (ppmC/wet)	1637.5	52.7	1724.3	1398.3	1157.5	120.9	669.8	48.8
Ethanol Emissions								
Ethanol Conc. (ppmv/wet) 1	1286.7	NOGC	1462.5	1190	1041	NO GC	509	S
Ethanol Conc. (ppmv/wet) [2]	1498.3	48.2	1446.7	1230.5	1026.7	107.2	SOS.7	36.8
Ethanol/THC Ratio	0.915	0.915 [a]	0.839	0.88	0.887	0.887 [a]	0.755	0.755 [a]
Ethanol Emission Rate (lb/hr) [1]	8.65	NO GC	8.55	10.73	2.78	NO CC	3.42	S
Ethanol Emission Rate (lb/hr) [2]	10.08	0.26	8.46	11.09	2.75	4.02	3.40	0.20
Total Ethanol Emission Rate (lbs/hr) [2]	14.819 [b]		22.187 [c]		2.746	4.024	8.083 [b]	
Acetaldehyde Emissions								
Acetaldehyde Conc. (ppmv/wet) [1]	39.10	NO GC	60.10	46.20	26.60	NO GC	16.00	5.36
Acetaldehyde Conc. (ppmv/wet) [2]	46.51	1.50	59.49	47.40	26.28	2.74	15.94	5.22
Acetaldehyde/THC Ratio	0.028	0.028 [a]	0.035	0.034	0.023	0.023 [a]	0.024	0.107
Acetaldehyde Emission Rate (lb/hr) [1]	0.252	NO GC	0.336	0.398	0.068	NO GC	0.103	0.027
Acetaldehyde Emission Rate (lb/hr) [2]	0.299	0.008	0.333	0.409	0.067	0.099	0.103	0.027
Total Acetaldehyde Emission Rate (lbs/hr) [2]	0.417 [b]		0.806 [c]		0.067	0.099	0.239 [b]	

1 Values calculated from average concentrations determined from multiple GC analyses.

2 Values calculated from average Ethanol/THC and Acetaldehyde/THC ratios (ETOH/THC and AA/THC) incorporating both GC and THC analyses: ETOH Conc. = Avg (ETOH$_i$/THC$_i$) • (Avg THC): ETOH Emissions = (Avg ETOH Conc.) * Flow
AA Conc. = Avg (AA$_i$/THC$_i$) • (Avg THC): AA Emissions = (Avg AA Conc.) * Flow

a Assumed value taken from similar location.

b Incorporated average Line 2 C.H. emissions of 4.49 ethanol and 0.110 acetaldehyde from Runs 9 & 11

c Incorporated average Line 1 C.H. emissions of 2.64 ethanol and 0.065 acetaldehyde from Runs 8 & 11

d Comfort Hood flow rates for this site were estimated based on velocity pressures or hot wire anemometer velocity measurements. Measurement locations did not meet EPA 1 specifications.

S Suspect GC ethanol results.

Table 3–9. Ethanol and Acetaldehyde Emissions Test Results (cont.)
EPA Bakeries, Site 2 (1992)

Run	Run 11 [b]		Run 12		
Stack Location	**L1 C.H.**	**L2 C.H.**	**Front**	**Comfort**	**Rear**
THC Conc. (ppmC/wet)	1067.6	148.7	4114.2	638.9	2992.1
Ethanol Emissions					
Ethanol Conc. (ppmv/wet) [1]	NO GC	NO GC	2777.5	NO GC	1651
Ethanol Conc. (ppmv/wet) [2]	947.0	131.9	2686.6	566.7	1621.7
Ethanol/THC Ratio	0.887 [a]	0.887 [a]	0.653	0.887 [a]	0.542
Ethanol Emission Rate (lb/hr) [1]	NO GC	NO GC	40.35	NO GC	23.11
Ethanol Emission Rate (lb/hr) [2]	2.53	4.95	39.03	2.85	22.70
Total Ethanol Emission Rate (lbs/hr) [2]	2.533	4.949	64.577		
Acetaldehyde Emissions					
Acetaldehyde Conc. (ppmv/wet) [1]	NO GC	NO GC	112.40	NO GC	71.80
Acetaldehyde Conc. (ppmv/wet) [2]	24.23	3.38	107.79	14.50	70.31
Acetaldehyde/THC Ratio	0.023 [a]	0.023 [a]	0.026	0.023 [a]	0.024
Acetaldehyde Emission Rate (lb/hr) [1]	NO GC	NO GC	1.562	NO GC	0.961
Acetaldehyde Emission Rate (lb/hr) [2]	0.062	0.121	1.498	0.070	0.941
Total Acetaldehyde Emission Rate (lbs/hr) [2]	0.062	0.121	2.509		

1 Values calculated from average concentrations determined from multiple GC analyses.

2 Values calculated from average Ethanol/THC and Acetaldehyde/THC ratios (ETOH/THC and AA/THC) incorporating both GC and THC analyses: ETOH Conc. = Avg ($ETOH_i / THC_i$) * (Avg THC): ETOH Emissions = (Avg ETOH Conc.) * Flow

AA Conc. = Avg (AA_i / THC_i) * (Avg THC): AA Emissions = (Avg AA Conc.) * Flow

a Assumed value taken from similar location.

b Comfort Hood flow rates for this site were estimated based on velocity pressures or hot wire anemometer velocity measurements. Measurement locations did not meet EPA 1 specifications.

3.3.4 Site 2 Method 25A and Method 18 Results

Tables 3-10 and 3-11 present the Method 25A and Method 18 analytical results from the oven stacks and burner stacks, respectively. The ethanol-to-THC proportions for the Line 1 and Line 2 oven front stacks were approximately 0.8-0.9.

The Method 25A and Method 18 results for Site 2 are presented graphically in Figures 3-6 through 3-12, respectively. Method 18 concentrations have been corrected to ppmC for these plots.

3.3.5 Stack Gas Flow Rates

Table 3-12 presents the stack gas flow rates determined for the Site 2 oven stacks.

3.4 Site 3 Test Results

A small bun oven and another small oven designated for baking bread were tested at Site 3. The bun oven was identified as indirect-fired with three stacks. Two of the three stacks were designated for the two burners and the third (exhauster) stack vented oven gases. During normal operation, the main flow damper on this oven was closed and only 50-100 acfm of stack gas flow was present during testing. The tests were conducted with one sampling/THC analytical system on the exhauster stack and alternating the other sample/THC system from "Burner 1" and "Burner 2".

Table 3– 10. Method 25A and Method 18 Emissions Tests Results, Front Stack, EPA Bakeries, Site 2 (1992).

FRONT/OVEN STACK									
RUN	TIME	METHOD 25A THC RESULTS[a] (ppmC/wet)	METHOD 18 GC RESULTS			GC/THC RATIO [b] (%)	THC PROPORTIONS [c]		
			ETHANOL (ppmv/wet)	METHANE [d] (ppmv/wet)	ACET–ALDEHYDE (ppmv/wet)		ETH/THC RATIO	CH4/THC RATIO	AA/THC RATIO
6	11:32:49	1042.9	1062	0.00/0.83	37.8	149.223	1.018	0.002	0.036
6	11:45:49	1647.3	1338	3.60/0.67	29.6	117.849	0.812	0.003	0.018
6	11:55:49	1594.4	1460	2.30/1.26	49.8	134.172	0.916	0.003	0.031
6	AVG	t8s7.5	1288.7	3.8	39.1	133.7	0.915	0.003	0.028
	12:06:49	1696.8	1201	6.5	7.06	101.462	0.708	o.ooo	0.005
7	15:17:30	1778.2	1490	4.82/17.1	62.5	125.506	0.838	0.022	0.035
7	15:35:54	1590.6	1300	3.54/12.4	53.2	121.951	0.817	0.018	0.033
7	15:54:54	1801.3	1530	4.72/19.0	65.1	127.428	0.849	0.024	0.036
7	16:13:54	1792.9	1530	4.75/8.80	59.5	126.507	0.853	0.012	0.033
7	AVG	1724.3	1462.5	33.1	80.1	125.3	0.839	0.019	0.034
8	16:24:34	1173.9	1041	1.80/5.70	26.6	129.835	0.887	0.011	0.023
8	AVG	1157.5	1041.0	13.2	26.6	129.8	0.887	0.011	0.023
10	16:56:39	681.0	550	2.26/0.21	17.1	118.173	0.806	0.004	0.025
10	17:15:09	646.2	532	2.34/0.20	17	120.564	0.823	0.004	0.026
10	17:34:09	701.2	445	2.54/0.00	14	92.9263	0.635	0.004	0.020
10	AVG	669.8	509.0	2.7	16.0	110.6	0.755	0.004	0.024

[a] THC averages calculated from the full CEM data base (not just the above entries)

[b] GC/THC RATIO = (ETOH/1.42+AA/1.23+CH4)/THC • 100 where: 1.42 = Ethanol CECF
1.23 = Acetaldehyde CECF

[c] THC proportions were calculated as:ETH/THC = ppmv ethanol/ppmC THC, CH4/THC = ppmv CH4/ pmC THC,

[d] Methane/Ethane Values are reported here. Averages are in units of ppmC. AA/THC = ppmv acetaldehyde/ ppmC THC

Table 3-10. Method 25A and Method 18 Emissions Tests Results (cont), Front Stacks, EPA Bakeries, Site 2 (1992).

FRONT/OVEN STACK									
RUN	TIME	METHOD 25A THC RESULTS[a] (ppmC/wet)	METHOD 18 GC RESULTS ETHANOL (ppmv/wet)	METHANE (ppmv/wet)	ACET-ALDEHYDE (ppmv/wet)	GC/THC RATIO [b] (%)	THC PROPORTIONS [c] ETH/THC RATIO	CH4/THC RATIO	AA/THC RATIO
NA	16:21:55	813.4	2900	491	97.7	609.9	3.565	0.604	0.120
i2	16:03:46	4250.1	3290	826	125	133.0	0.774	0.194	0.029
12	18:23:16	3907.5	2590	1411	91.4	133.1	0.663	0.361	0.023
12	18:42:16	4588.5	2390	1540	131	111.0	0.521	0.336	0.029
12	19:01:16	4320.7	2840	1330	102	127.0	0.657	0.308	0.024
12	AVG	4114.21	2777.5	1193.0	105.5	126.0	1.352	0.402	0.049

[a] THC averages calculated from the full CEM data base (not just the above entries)

[b] GC/THC RATIO = (ETOH/1.42+AA/1.23+CH4)/THC * 100 where: 1.42 = Ethanol CECF

1.23 = Acetaldehyde CECF

[c] THC proportions were calculated as:ETH/THC = ppmv ethanol/ppmC THC, CH4/THC = ppmv CH4/ pmC THC, AA/THC = ppmv acetaldehyde/ ppmC THC

Table 3– 11 Method 25A and Method 18 Emissions Tests Results, Rear Stacks, EPA Bakeries, Site 2 (1992).

REAR/BURNER STACK									
RUN	TIME	METHOD 25A THC RESULTS[a] (ppmC/wet)	METHOD 18 GC RESULTS			GC/THC RATIO[b] (%)	THC PROPORTIONS[c]		
			ETHANOL (ppmv/wet)	METHANE[d] (ppmv/wet)	ACET–ALDEHYDE (ppmv/wet)		ETH/THC RATIO	CH4/THC RATIO	AA/THC RATIO
7	15:27:54	1763.4	1200.0	3.76/13.9[d]	50.1	101.916	0.834	0.016	0.035
7	15:45:54	1475.7	1250.0	4.10/14.8	49.9	126.723	0.647	0.023	0.034
7	16:03:54	1166.1	1120.0	2.57/8.80	30.5	142.170	0.960	0.017	0.033
7	AVG	1398.3	1190.0	28.5	48.2;	123.6	0.880	0.0191	0.034
10	16:48:09	56.3	65.7	2.02/.53	4.63	231.935	1.523	0.055	0.082
10	17:06:09	57.2	195.0	3.85/ND	7.24	499.641	3.410	0.067	0.127
10	17:24:39	36.0	97.0	2.54/ND	4.6	360.360	2.574	0.067	0.121
10	17:44:09	51.6	115.0	1.96/0.59	4.96	333.332	2.222	0.061	0.096
10	AVG	384.0	123.4	3.2	5.4	361.4	2.432	0.062	0.106

[a] THC averages calculated from the full CEM data base (not just the above entries)

[b] GC/THC RATIO = (ETOH/1.42+AA/1.23+CH4)/THC • 100 where: 1.42 = Ethanol CECF
1.23 = Acetaldehyde CECF

[c] THC proportions were calculated as: ETH/THC = ppmv ethanol/ppmC THC, CH4/THC = ppmv CH4/ ppmC THC, AA/THC = ppmv acetaldehyde/ ppmC THC

[d] Methane/Ethane values reported here. Averages in units ppmC.

ND = Not detected

Table 3-I 1. Method 25A and Method 18 Emissions Tests Results (cont), Rear Stack, EPA Bakeries, Site 2 (1992).

REAR/BURNER STACK									
RUN	TIME	METHOD 25A THC RESULTS' (ppmC/wet)	METHOD 18 GC RESULTS ETHANOL (ppmv/wet)	METHANE (ppmv/wet)	ACET-ALDEHYDE (ppmv/wet)	GC/THC RATIO [b] (%)	THC PROPORTIONS [c] ETH/THC RATIO	CH4/THC RATIO	AA/THC RATIO
12	15:54	3146.6	1710.0	1980.0	78.4	143.2	0.543	0.629	0.025
12	16:12:46	3105.4	1750.0	1550.0	82.0	133.2	0.564	0.499	0.026
12	16:30:46	2944.3	1820.0	1970.0	78.2	158.0	0.618	0.669	0.027
12	16:49:16	2900.5	1580.0	185.0	19.0	84.5	0.545	0.064	0.007
12	17:22:46	3040.4	1220.0	1990.0	72.3	125.4	0.401	0.655	0.024
12	17:52:46	2974.9	1390.0	2050.0	74.3	138.3	0.467	0.689	0.025
12	18:04:16	2798.2	1480.0	2030.0	66.7	150.6	0.509	0.698	0.023
12	18:33:16	2934.0	1660.0	1960.0	76.9	150.4	0.566	0.668	0.026
12	18:51:46	3177.2	1850.0	1940.0	83.4	147.0	0.582	0.611	0.026
12	19:10:16	3259.6	2050.0	2110.0	86.4	157.3	0.629	0.647	0.027
12	AVG	2992.1	1651.0	1776.5	71.8	138.8	0.542	0.583	0.024

[a] THC averages calculated from the full CEM data base (not just the above entries)

[b] GC/THC RATIO = (ETOH/1.42+AA/1.23+CH4)/THC • 100 where: 1.42 = Ethanol CECF
1.23 = Acetaldehyde CECF

[c] THC proportions were calculated as:ETH/THC = ppmv ethanol/ppmC THC, CH4/THC = ppmv CH4/ pmC THC,
AA/THC = ppmv acetaldehyde/ ppmC THC

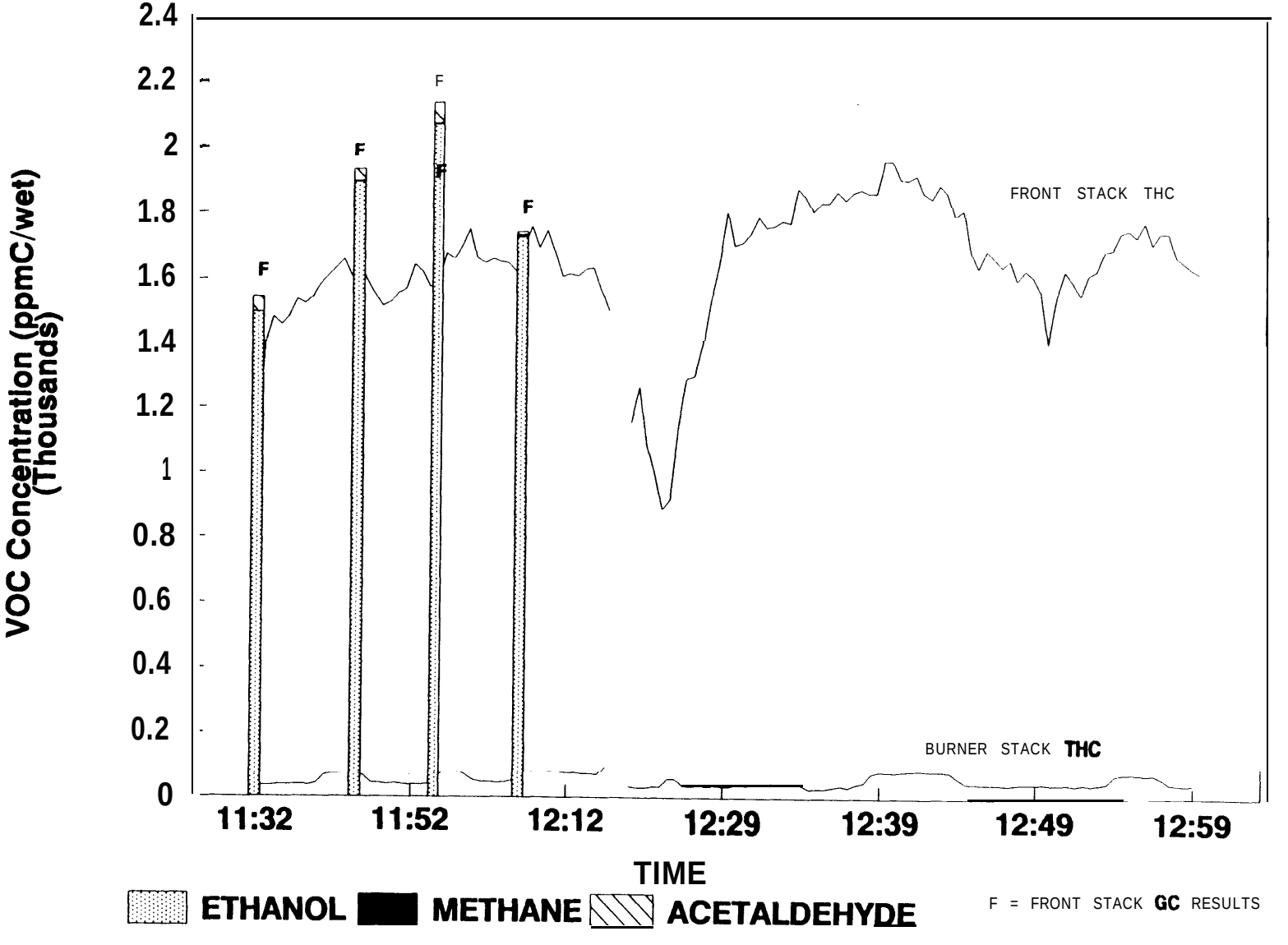

Figure 3-6. Run 6 Method 25A and Method 18 Results (adjusted to ppmC) .

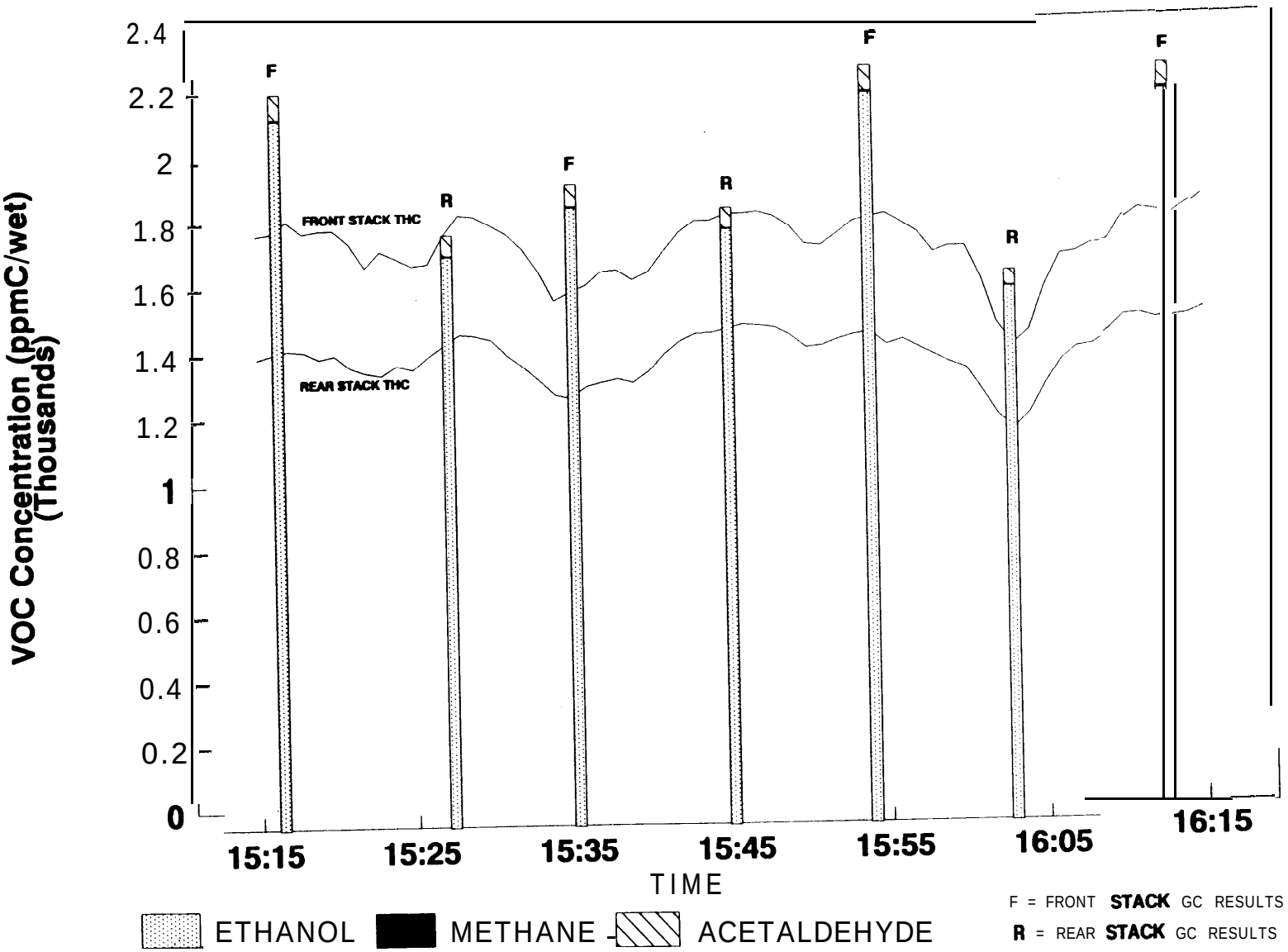

Figure 3-7. Run 7 Method 25A and Method 18 Results (adjusted to ppmC) .

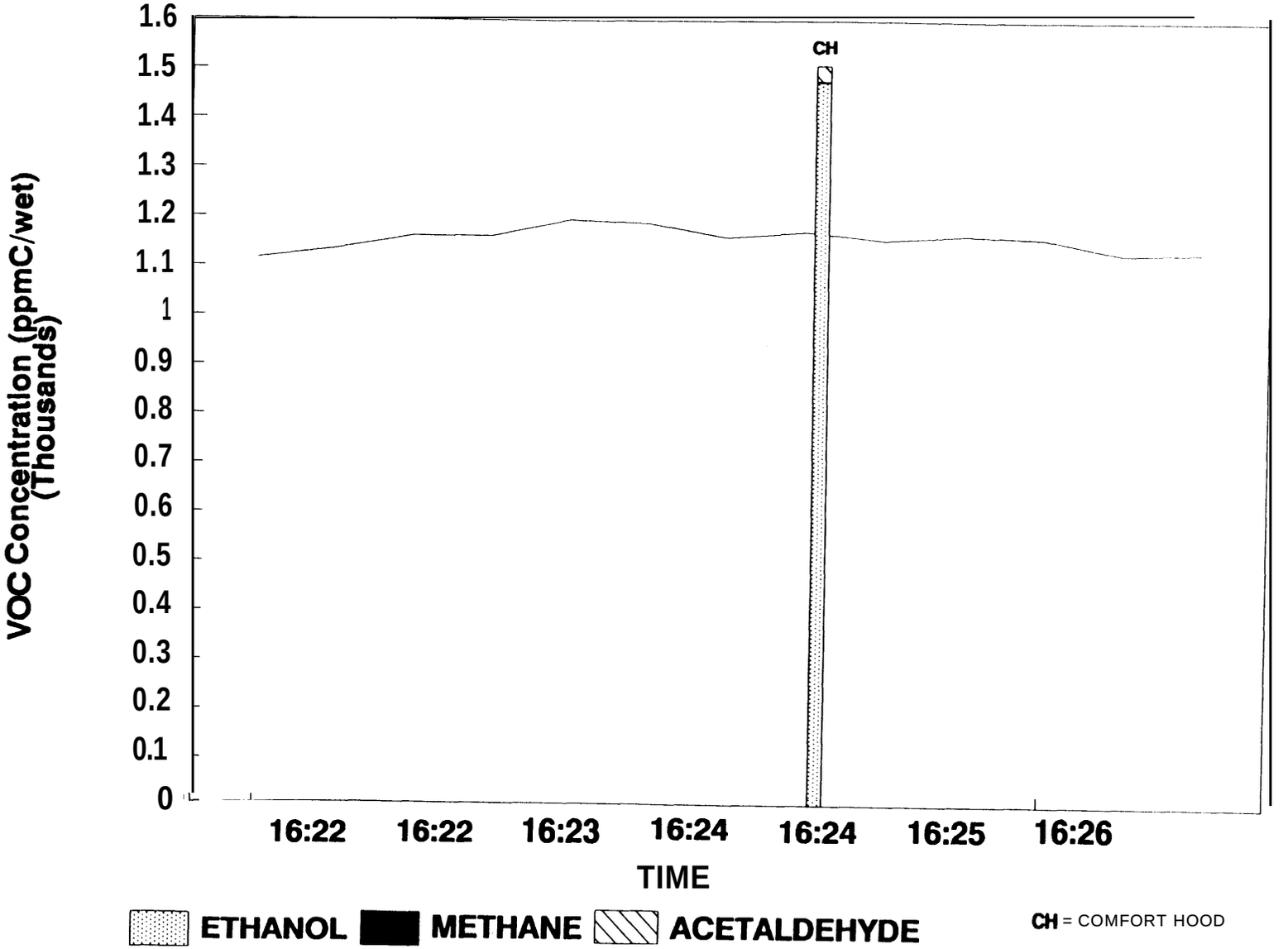

Figure 3-8. Run 8 Method 25A and Method 18 Results (adjusted to ppmC) .

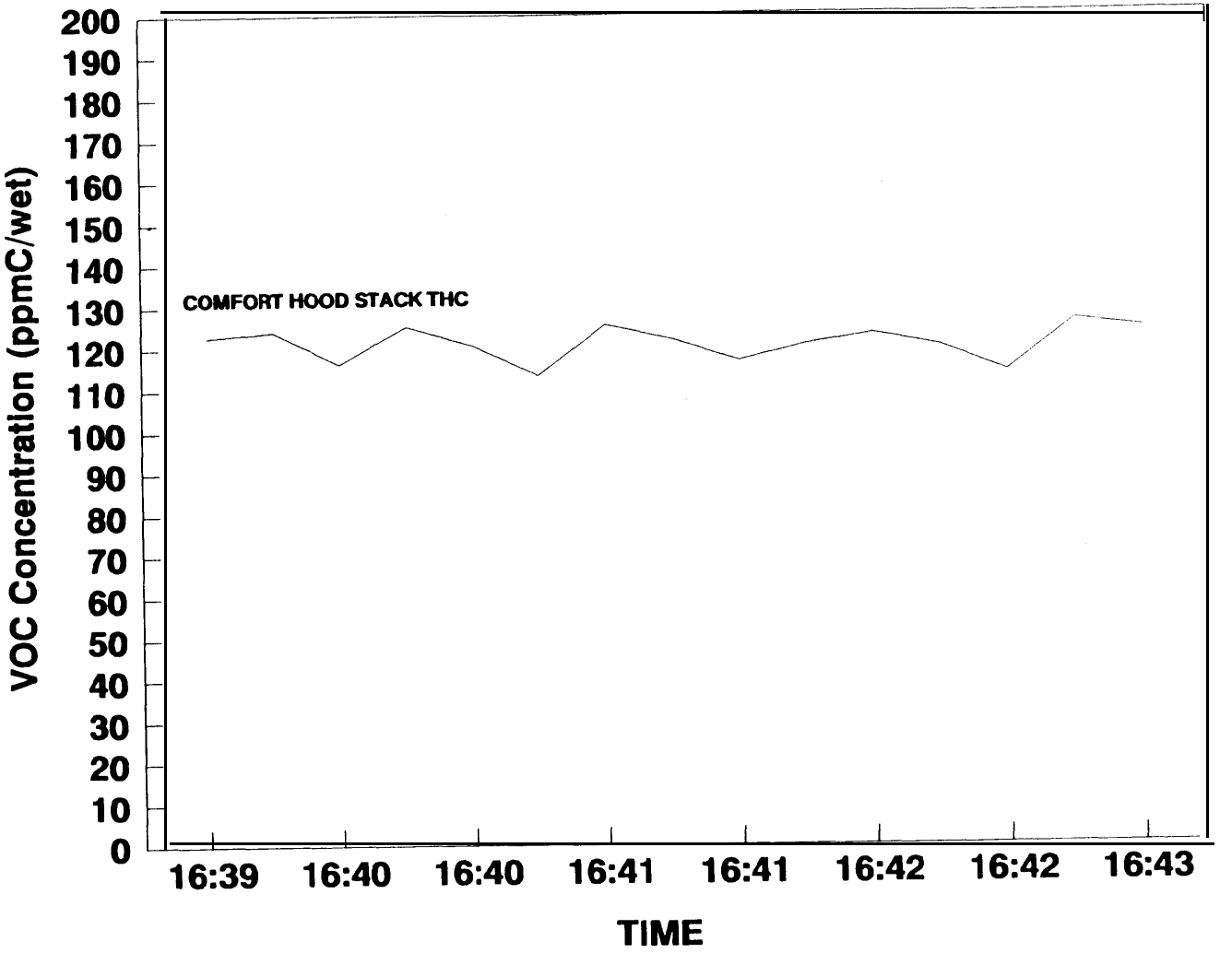

Figure 3-9. Run 8 Method 25A and Method 18 Results (adjusted to ppmC) .

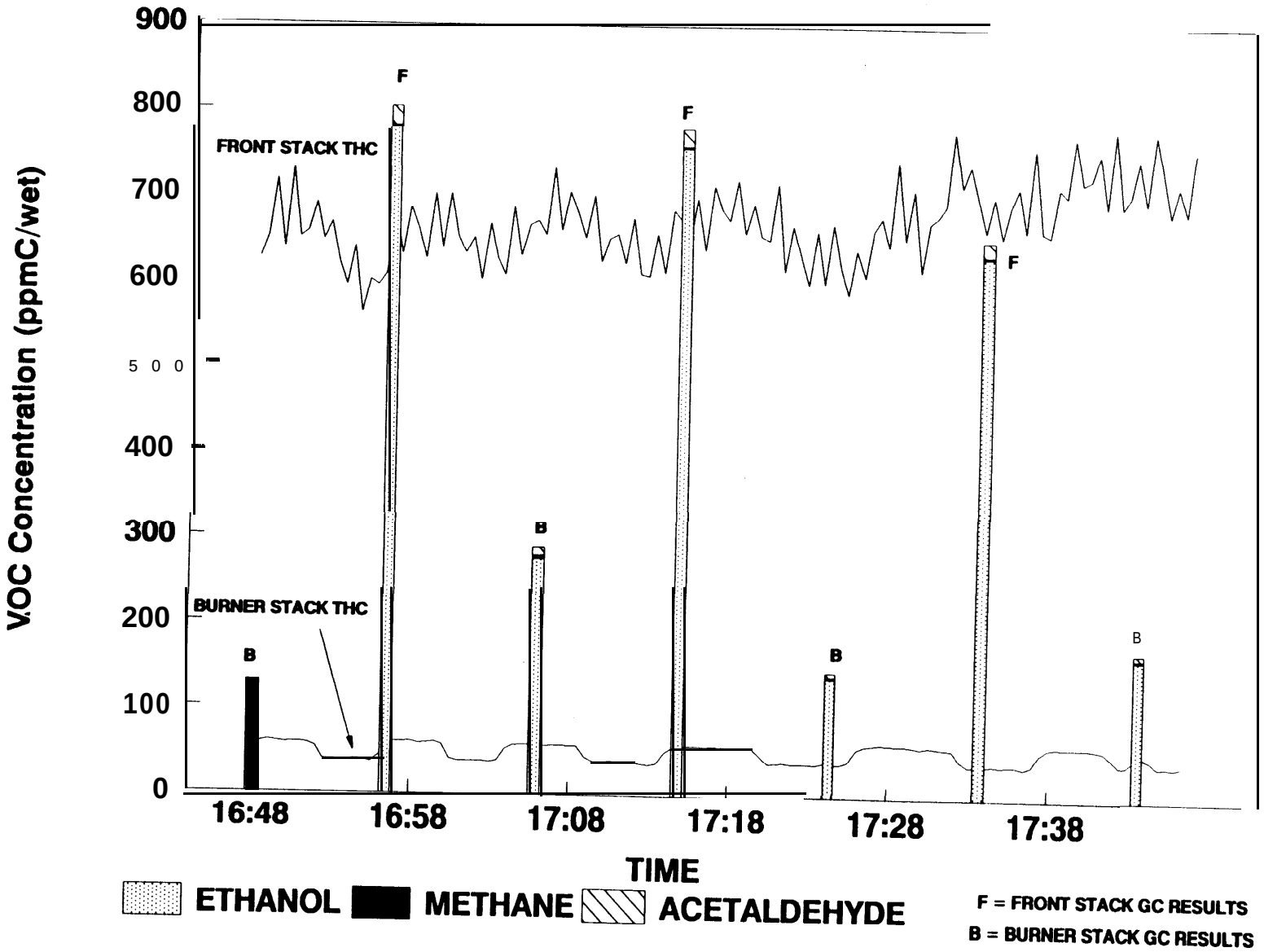

Figure 3-10. Run 10 Method 25A and Method 18 Results (adjusted to ppmC) .

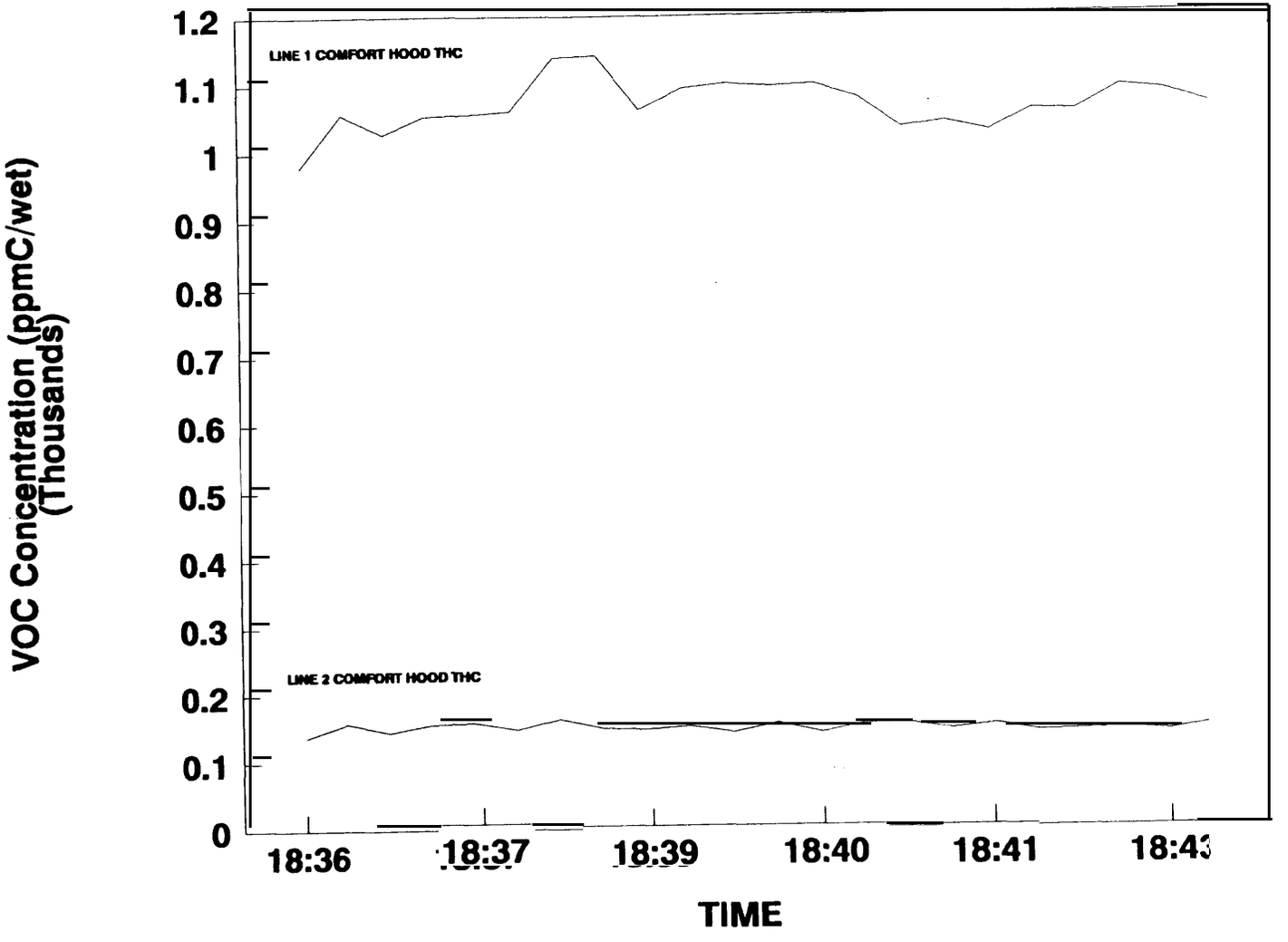

Figure 3-11. Run 11 Method 25A Results

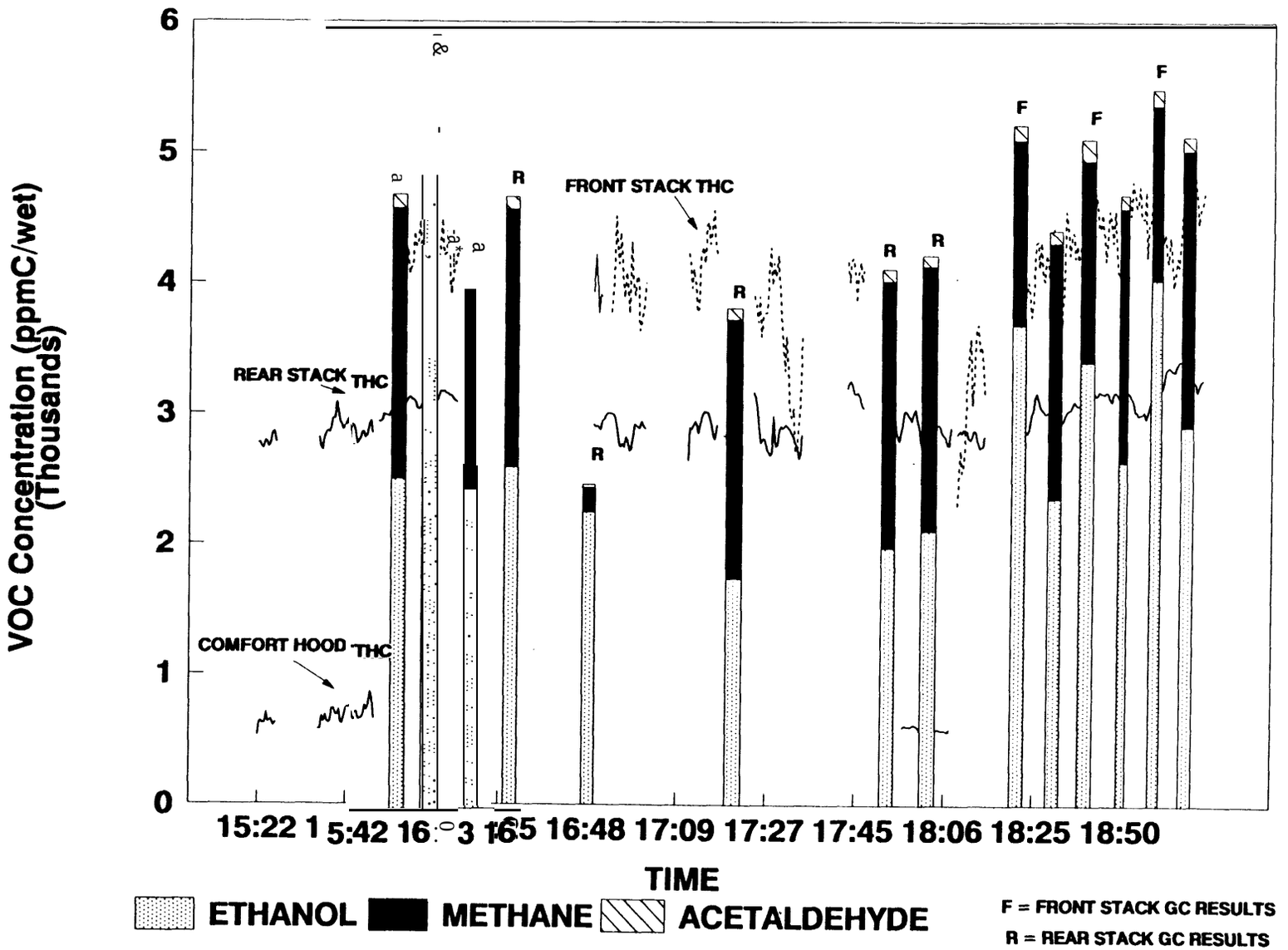

Figure 3-12. Run 12 Method 25A and Method 18 Results (adjusted to ppmC) .

Table 3 – 12. Summary of Flue Gas Sampling Parameters
Site 2 (1992)

Run Number	Location	Stack Gas Temperature (deg F)	Barometric Pressure (in. Hg)	stack Gas Static Pressure (in H2O)	Volumetric Flow Rate (acfm)	Volumetric Flow Rate (scfm)
Run 6	Front	230	30.21	-0.1	1,216	939
	Burner	316	30.21	-0.05	1,083	744
Run 7	Front	269	30.21	-0.1	1,116	811
	Rear	309	30.21	-0.2	1,816	1,251
Run 8	Comfort	207	30.21	0	467	371
Run 9	Comfort	108	30.21	0	5,585	5,242
Run 10	Front	230	30.2 1	-0.1	1,216	939
	Burner	316	30.21	-0.2	1,083	744
Run 11	L1 C.H.	207	30.21	0	467	371
	L2 C.H.	108	30.21	0	5,585	5,242
Run 12	Front	216	30.01	-0.25	2,593	2,013
	Comfort	100	30.01	0	742.45	702.12
	Rear	214	29.75	-0.15	25 12.22	1,957

3.4.1 Site 3 Test Log

Nine emissions test runs were conducted on June 22 and 24, 1992. Runs 13, 14, and 18 were conducted on the Bun oven. Runs 15-17 and 19-21 were conducted on the Bread oven. Table 3-13 presents a summary of the Site 3 sampling activities.

3.4.2 Site 3 VOC as Ethanol Emissions Test Results

Table 3-14 presents the VOC as ethanol test results.

3.4.3 Site 3 Ethanol and Acetaldehyde Emission Test Results

Table 3-15 presents the emission rates of ethanol and acetaldehyde.

3.4.4 Site 3 Method 25A and Method 18 Results

Tables 3-16 and 3-17 present the Method 25A and Method 18 analytical results from the oven stacks and burner stacks, respectively.

The Site 3 Method 25A and Method 18 results are presented graphically for Runs 13-21 in Figures 3-13 through 3-21, respectively. Method 18 concentrations have been corrected to ppmC for these plots.

Table 3-13

Site 3 Bakery VOC Emissions Test Log EPA Bakeries (1992)

Run	Date	Sampling Time	Oven & Product Designation	Number of GC injections	
				Front	Rear
13	6/22/92	10:49-11:11	Bun I'	2	2
14	6/22/92	11:32-11:59	Bun I	2	1
15	6/22/92	12:03-13:31	Bread J	6	4
16	6/22/92	14:07-15:11	Bread K	4	3
17	6/22/92	15:46-16:42	Bread L	3	3
18	6/24/92	10:15-11:15	Bun M	4	3
19	6/24/92	11:42-12:10	Bread N	1	2
20	6/24/92	14:39-15:26	Bread K	3	2
21	6/24/92	16:01-17:08	Bread L	3	4

Table 3–14. VOC Emissions Assuming 100 % Ethanol
EPA Bakeries, Site 3 (1992)

Run	Run 13			Run 14			Run 15	
Stack Location	**Exhauster**	**Burner 1**	**Burner 2**	**Exhauster**	**Burner 1**	**Burner 2**	**Oven**	**Burner**
THC Conc. (ppmC/wet)	1422.7	1223.7	1051.8	1043.0	838.5	829.8	1878.2	946.2
Methane Concentrations								
Methane Conc. (ppmv/wet) [1]	2.3	12.1	8.0	0.5	NO GC	4.0	496.1	427.1
Methane/THC Ratio	0.002	0.009	0.007	0.0005	NO GC	0.005	0.244	0.529
Methane Conc. (ppmC/wet) [2]	2.845	11.01	7.363	0.522	0 [a]	4.149	458.3	500.5
VOC Emissions								
VOC Conc. (ppmC/wet) [3]	1419.9	1212.7	1044.4	1043.0	838.5	825.7	1419.9	445.7
VOC Conc. as Ethanol (ppmv/wet) [4]	999.9	854.0	735.5	734.5	590.5 [a]	581.4	999.9	313.8
VOC Emission Rate as Ethanol (lb/hr) [4]	0.24	2.07	2.26	0.18	1.43	1.78	11.55	1.13
Total VOC Emissions as Ethanol (lbs/hr) [4]	4.739			3.390			12.676	

[1] Values calculated from average methane concentrations determined from multiple GC analyses.

-- Values calculated from average Methane to THC ratios (CH4/THC) incorporating both GC and THC analyses:

[2] Methane Conc. = Avg ($CH4_i / THC_i$) * (Avg THC)

[3] VOC Conc. = Avg ($1 - CH4_i / THC_i$) * (Avg THC)

[4] VOC Conc. as Ethanol = (VOC Conc) / 1.42 VOC Emissions as Ethanol = (VOC Conc. as Ethanol) * Flow;
where 1.42 is the empirically derived carbon equivalent correction factor

[a] GC analyses was not performed for this location; therefore, the VOC concentration was assumed to be 100 % of the THC conc.

Table 3–14. VOC Emissions Assuming 100 % Ethanol (cont.)
EPA Bakeries, Site 3 (1992)

Run	Run 16		Run 17		Run 18		
Stack Location	**Oven**	**Burner**	**Oven**	**Burner**	**Exhauster**	**Burner 1**	**Burner 2**
THC Conc. (ppmC/wet)	2323.2	951.9	2353.3	943.9	1221.6	939.7	924.4
Methane Concentrations							
Methane Conc. (ppmv/wet) [1]	506.9	1236.3	679.3	1656	1.7	5.2	6.8
Methane/THC Ratio	0.198	0.868	0.320	0.991	0.001	0.006	0.007
Methane Conc. (ppmC/wet) [2]	460.0	826.2	753.1	935.4	1.222	5.638	6.471
VOC Emissions							
VOC Conc. (ppmC/wet) [3]	1863.2	125.7	1600.2	8.5	1220.4	934.1	917.9
VOC Conc. as Ethanol (ppmv/wet) [4]	1312.1	88.5	1126.9	6.0	859.4	657.8	646.4
VOC Emission Rate as Ethanol (lb/hr) [4]	15.15	0.32	13.02	0.02	0.20	1.59	1.98
Total VOC Emissions as Ethanol (lbs/hr) [4]	15.473		13.038		3.782		

1 Values calculated from average methane concentrations determined from multiple GC analyses.

-- Values calculated from average Methane to THC ratios (CH4/THC) incorporating both GC and THC analyses:

2 Methane Conc. = Avg ($CH4_i / THC_i$) * (Avg THC)

3 VOC Conc. = Avg ($1 - CH4_i / THC_i$) * (Avg THC)

4 VOC Conc. as Ethanol = (VOC Conc) / 1.42 VOC Emissions as Ethanol = (VOC Conc. as Ethanol) * Flow;
where 1.42 is the empirically derived carbon equivalent correction factor

Table 3–14. VOC Emissions Assuming 100 % Ethanol (cont.)
EPA Bakeries, Site 3 (1992)

Run	Run 19		Run 20		Run 21	
Stack Location	**Oven**	**Burner**	**Oven**	**Burner**	**Oven**	**Burner**
THC Conc. (ppmC/wet)	2027.6	1090.2	2513.6	966.2	2552.1	1002.1
Methane Concentrations						
Methane Conc. (ppmv/wet) [1]	1274.5	1875.0	515.3	1475.3	705.8	839.7
Methane/THC Ratio	0.566	1.638	0.206	1.106	0.271	0.735
Methane Conc. (ppmC/wet) [2]	1147.6	1785.7	517.8	1068.6	691.6	736.5
VOC Emissions						
VOC Conc. (ppmC/wet) [3]	880.0	−695.5	1995.8	−102.4	1860.5	265.6
VOC Conc. as Ethanol (ppmv/wet) [4]	619.7	88.5 [a]	1405.5	88.5 [a]	1310.2	187.0
VOC Emission Rate as Ethanol (lb/hr) [4]	7.16	0.32	16.23	0.32	15.13	0.67
Total VOC Emissions as Ethanol (lbs/hr) [4]	7.475 [a]		16.551 [a]		15.804	

1 Values calculated from average methane concentrations determined from multiple GC analyses.

-- Values calculated from average Methane to THC ratios (CH4/THC) incorporating both GC and THC analyses:

2 Methane Conc. = Avg ($CH4_i / THC_i$) * (Avg THC)

3 VOC Conc. = Avg ($1 - CH4_i / THC_i$) * (Avg THC)

4 VOC Conc. as Ethanol = (VOC Conc) / 1.42 VOC Emissions as Ethanol = (VOC Conc. as Ethanol) * Flow; where 1.42 is the empirically derived carbon equivalent correction factor

a High methane results resulted in negative VOC concentrations; therefore, VOC conc. as Ethanol for these runs/rear stack, were assumed to be identical to Run 16, rear stack which was tested while baking an identical product.

Table 3–15. Ethanol and Acetaldehyde Emissions Test Results EPA Bakeries, Site 3 (1992)

Run	Run 13			Run 14			Run 15	
Stack Location	Exhauster	Burner 1	Burner 2	Exhauster	Burner 1	Burner 2	Oven	Burner
THC Conc. (ppmC/wet)	1422.7	1223.7	1051.8	1043.0	838.5	829.8	1878.2	946.2
Ethanol Emissions								
Ethanol Conc. (ppmv/wet) [1]	1281.9	840.6	680.5	853.9	573.6	573.6	832.7	71.6
Ethanol Conc. (ppmv/wet) [2]	1298.9	807.6	671.0	852.1	562.6	556.8	820.8	90.8
Ethanol/THC Ratio	0.913	0.66	0.638	0.817	0.671 [a]	0.671	0.437	0.096
Ethanol Emission Rate (lb/hr) [1]	0.31	2.04	2.09	0.20	1.39	1.76	9.62	0.26
Ethanol Emission Rate (lb/hr) [2]	0.31	1.96	2.06	0.20	1.36	1.71	9.48	0.33
Total Ethanol Emission Rate (lbs/hr) [2]	4.325			3.275			9.806	
Acetaldehyde Emissions								
Acetaldehyds Conc. (ppmv/wet) [1]	25.30	70.6	34.50	18.47	40.7	40.7	23.20	5.10
Acetaldehyde Conc. (ppmv/wet) [2]	25.61	67.79	33.97	18.46	40.00	3958	22.54	23.94
Acetaldehyde/THC Ratio	0.018	0.055	0.032	0.018	0.048	0.048	0.012	0.025
Acetaldehyde Emission Rate (lb/hr) [1]	0.006	0.164	0.101	0.004	0.094	0.119	0.256	0.018
Acetaldehyde Emission Ra te (lb/hr) [2]	0.006	0.157	0.100	0.004	0.093	0.116	0.249	0.082
Total Acetaldehyde Emission Rate (lbs/hr) [2]	0.263			0.213			0.331	

[1] Values calculated from average concentrations determined from multiple GC analyses.

[2] Values calculated from average Ethanol/THC and Acetaldehyde/THC ratios (ETOH/THC and AA/THC) incorporating both GC and THC analyses: ETOH Conc. = Avg (ETOH i /THC i) * (Avg THC): ETOH Emissions = (Avg ETOH Conc.) * Flow

AA Conc. = Avg (AA i /THC i) * (Avg THC): AA Emissions = (Avg AA Conc.) * Flow

[a] Assumed value taken from similar location.

Table 3–15. Ethanol and Acetaldehyde Emissions Test Results (cont.)
EPA Bakeries, Site 3 (1992)

Run	Run 16		Run 17		Run 18		
Stack Location	Oven	Burner	Oven	Burner	Exhauster	Burner 1	Burner 2
THC Conc. (ppmC/wet)	2323.2	9s1.9	2353.3	943.9	1221.6	939.7	924.4
Ethanol Emissions							
Ethanol Conc. (ppmv/wet) [1]	1105.7	86	997	82.7	954.8	811	595.6
Ethanol Conc. (ppmv/wet) [2]	971.1	56.8	1061.3	53.8	984.6	796.9	594.4
Ethanol/THC Ratio	0.418	0.060	0.45 1	0.057	0.806	0.848	0.643
Ethanol Emission Rate (lb/hr) [1]	12.77	0.31	11.52	0.30	0.23	1.96	1.83
Ethanol Emission Rate (lb/hr) [2]	11.22	0.20	12.26	0.19	0.23	1.93	1.82
Total Ethanol Emirrion Rata (lbs/hr) [2]	11.420		12.452		3.989		
Acetaldehyde Emissions							
Acetaldehyde Conc. (ppmv/wet) [1]	31.40	6.90	22.50	5.55	20.10	35.4	SO.00
Acetaldehyde Conc. (ppmv/wet) [2]	31.60	5.14	26.12	7.36	20.77	36.74	SO.84
Acetaldehyde/THC Ratio	0.014	0.005	0.011	0.008	0.017	0.039	0.055
Acetaldehyde Emission Rate (lb/hr) [1]	0.347	0.024	0.249	0.019	0.005	0.082	0.147
Acetaldehyde Emission Rate (lb/hr) [2]	0.349	0.018	0.289	0.025	0.005	0.085	0.149
Total Acetaldehyde Emission Rate (lbs/hr) [2]	0.367		0.314		0.239		

[1] Values calculated from average concentrations determined from multiple GC analyses.

[2] Values calculated from average Ethanol/THC and Acetaldehyde/THC ratios (ETOH/THC and AA/THC) incorporating both GC and THC ● nalyuea: ETOH Conc. = Avg (ETOH i /THC i) * (Avg THC): ETOH Emissions = (Avg ETOH Conc.) * Flow

AA Conc. = Avg (AA ¡ /THC i) * (Avg THC): AA Emissions = (Avg AA Conc.) * Flow

Table 3–15. Ethanol and Acetaldehyde Emissions Test Results (cont.)
EPA Bakeries, Site 3 (1992)

Run	Run 19		Run 20		Run 21	
Stack Location	Oven	Burner	Oven	Burner	Oven	Burner
THC Conc. (ppmC/wet)	2027.6	1090.2	25 13.6	966.2	2552.1	1002.1
Ethanol Emissions						
Ethanol Conc. (ppmv/wet) [1]	460.5	46.2	S	1609	S	229.4
Ethanol Conc. (ppmv/wet) [2]	411.6	37.2	1383.2 •	123.7	1297.8 [a]	183.4
Ethanol/THC Ratio	0.203	0.0341	S	0.128	S	0.183
Ethanol Emission Rate (lb/hr) [1]	5.32	0.17	S	5.78	S	0.82
Ethanol Emission Rate (lb/hr) [2]	4.7s	0.13	15.98	0.44	14.99	0.66
Total Ethanol Emission Rate (lbs/hr) [2]	4.887		15.976 [a]		14.990 [a]	
Acetaldehyde Emissions						
Acetaldehyde Conc. (ppmv/wet) [1]	28.40	3.52	25.7	4.20	14.3	14.30
Acetaldehyds Conc. (ppmv/wet) [2]	25.35	3.38	25.64	4.73	29.35	11.52
Acetaldehyde/THC Ratio	0.013	0.003	0.010	0.005	0.012	0.012
Acetaldehyda Emission Rate (lb/hr) [1]	0.314	0.012	0.284	0.014	0.158	0.049
Acetaldehyda Emission Rate (lb/hr) [2]	0.280	0.012	0.283	0.016	0.324	0.040
Total Acetaldehyde Emission Rate (lbs/hr) [2]	0.292		0.300		0.364	

1 Values calculated from average concentrations determined from multiple GC analyses.

2 Values calculated from average Ethanol/THC and Acetaldehyde/THC ratios (ETOH/THC and AA/THC) incorporating both GC and THC analyses: ETOH Conc. = Avg (ETOH i /THC i) * (Avg THC): ETOH Emissions = (Avg ETOH Conc.) * F

AA Conc. = Avg (AA ¡ /THC ¡) * (Avg THC): AA Emissions = (Avg AA Conc.) * Flow

S = Suspect GC Analysis

a due to the invalidated ethanol GC results, this value was calculated as folows: {(VOC Conc.) – (AA Conc * 1.23)) / 1.42 where 1.23 and 1.42 are the carbon equivalent correction factors for AA:CH4 and Ethanol:CH4, respectively.

Table 3– 16. Method 25A and Method 18 Emissions Tests Results, Front (Oven) Stacks, EPA Bakeries, Site 3 (1992)

FRONT/OVEN STACK									
RUN	TIME	METHOD 25A THC RESULTS' (ppmC/wet)	METHOD 18 GC RESULTS ETHANOL (ppmv/wet)	METHANE (ppmv/wet)	ACET–ALDEHYDE (ppmv/wet)	GC/THC RATIO [b] (%)	THC PROPORTIONS [c] ETH/THC RATIO	CH4/THC RATIO	AA/THC RATIO
13	10:58:08	1404.4	1281.9	2.31	25.3	132.0	0.913	0.002	0.018
13	AVG	1422.71	1281.91	2.3	25.3	132.0	0.913	0.002	0.018
NA	11:16:38	386.2	388.9	0.63	8.82	148.0	1.007	0.002	0.023
14	11:36:38	1036.9	654.3	0.46	18.11	119.2	0.824	0.000	0.017
14	11:54:38	1054.3	853.4	0.56	18.63	117.2	0.809	0.001	0.018
14	AVG	1028.5	853.9	0.5	18.5	118.2	0.817	0.00050	0.018
15	12:03:38	1683.4	670.2	660.8	10.8	96.8	0.398	0.393	0.006
15	12:21:25	1413.4	752.2	180.4	22.4	90.3	0.532	0.128	0.016
15	12:40:25	2547.6	1246.1	655.3	33.1	96.8	0.489	0.257	0.013
15	12:58:25	2286.5	651.95	740.3	25.4	86.7	0.373	0.324	0.011
15	13:07:55	1655.8	935.5	23.3	22.93	83.3	0.565	0.014	0.014
15	13:25:55	2040.4	540.2	716.3	24.37	74.2	0.265	0.351	0.012
15	AVG	1878.2	832.7	496.1	23.2	88.0	0.437	0.244	0.012
16	14:14:27	2248.0	1265.4	567	30	108.1	0.572	0.207	0.013
16	14:32:27	2133.1	1362.7	375.6	32.1	110.2	0.639	0.176	0.015
16	14:50:27	2250.4	1029.9	578	32.2	92.4	0.456	0.211	0.014
16	AVG	2323.2	1226.0	506.9	31.4	103.6	0.558	0.198	0.014
NA	15:27:27	1104.5	132.95	900	7.71	99.4	0.120	0.671	0.007
17	15:45:27	1787.4	577	700	19.69	86.4	0.323	0.392	0.011
17	16:03:27	2381.8	1067	742	29	96.3	0.448	0.312	0.012
17	16:21:57	2310.3	1348	596	33.4	110.4	0.583	0.258	0.014
17	AVG	2353.3	997.3	879.8	27.4	97.7	0.451	0.320	0.013

[a] THC averages calculated from the full CEM data base (not just the above entries)

[b] GC/THC RATIO = (ETOH/1.42+AA/1.23+CH4)/THC * 100 where: 1.42 = Ethanol CECF, 1.23 = Acetaldehyde CECF

[c] THC proportions were calculated as:ETH/THC = ppmv ethanol/ppmC THC, CH4/THC = ppmv CH4/ pmC THC, AA/THC = ppmv acetaldehyde/ ppmC THC

NA= Not Applicable. Values were not used in the run averages.

Table 3-16. Method 25A and Method 18 Emissions Tests Results (cont), Front (Oven) Stacks, EPA Bakeries, Site 3 (1992).

FRONT/OVEN STACK									
RUN	TIME	METHOD 25ATHC RESULTS' (ppmC/wet)	METHOD 18 GC RESULTS ETHANOL (ppmv/wet)	METHANE (ppmv/wet)	ACET-ALDEHYDE (ppmv/wet)	GC/THC RATIO [b] (%)	THC PROPORTIONS [c] ETH/THC RATIO	CH4/THC RATIO	AA/THC RATIO
NA	16:39:57	2452.9	435	691.0	28.82	54.8	0.177	0.282	0.012
18	10:17:09	1122.3	905	1.1	18.9	116.7	0.806	0.001	0.017
18	10:34:59	1105.3	889	2.1	19.6	116.6	0.804	0.002	0.018
18	10:52:49	1326.0	1070	1.8	21.9	116.8	0.807	0.001	0.017
18	**AVG**	**1221.8**	**955**	**1.7**	20.1	**116.7**	**0.806**	0.001	0.017
NA	11:19:39	2135.1	733	531.0	19.3	74.7	0.343	0.249	0.009
NA	11:37:29	677.1	234	405.0	12.3	111.1	0.346	0.598	0.018
19	11:55:49	2284.9	579	779.0	30.8	71.7	0.253	0.341	0.013
19	12:13:39	2234.7	342	1770.0	26	102.4	0.153	0.792	0.012
19	**AVG**	2027.8	**461**	**1274.5**	**28.4**	87.1	**0.203**	0.566	**0.013**
NA	14:23:59	2277.0	155	792.0	13.9	45.2	0.068	0.348	0.006
20	14:41:59	2520.7	90	225.0	15.7	14.8	0.036	0.089	0.006
20	15:00:19	2696.4	367	669.0	33.2	45.7	0.136	0.248	0.012
20	15:18:29	2325.9	430	652.0	28.1	55.8	0.185	0.280	0.012
20	**AVG**	**2513.6**	**296**	515.9	25.7	38.7	**0.119**	0.206	**0.010**
NA	15:36:19	1683.6	221	1759.1	11.3	131.8	0.140	1.111	0.007
21	15:54:39	1904.1	205	408.0	22.5	38.1	0.108	0.213	0.012
21	16:13:09	2791.3	225	820.0	28.7	42.1	0.081	0.294	0.010
21	16:32:19	2701.7	884	761.0	31.7	76.1	0.327	0.282	0.012
21	16:50:09	2821.3	354	838.0	27.3	48.6	0.125	0.296	0.010
21	**AVG**	**2552.1**	**417**	**705.8**	**27.6**	**51.2**	**0.160**	**0.271**	**0.011**

[a] THC averages calculated from the full CEM data base (not just the above entries)

[b] GC/THC RATIO = (ETOH/1.42+AA/1.23+CH4)/THC * 100 where: 1.42 = Ethanol CECF
1.23 = Acetaldehyde CECF

[c] THC proportions were calculated as:ETH/THC = pprnv ethanol/ppmC THC, CH4/THC = ppmv CH4/ pmC THC,
NA = Not Applicable. Values were not used in the run averages. AA/THC = ppmv acetaldehyde/ ppmC THC

Table 3– 17. Method 25A and Method 18 Emissions Tests Results (cont), Rear (Burner) Stacks, EPA Bakeries, Site 3 (1992)

REAR/BURNER STACK									
RUN	TIME	METHOD 25A THC RESULTS[a] (ppmC/wet)	METHOD 18 GC RESULTS			GC/THC RATIO [b] (%)	THC PROPORTIONS [c]		
			ETHANOL (ppmv/wet)	METHANE (ppmv/wet)	ACET– ALDEHYDE (ppmv/wet)		ETH/THC RATIO	CH4/THC RATIO	AA/THC RATIO
13	10:49:08	1066.7	680.5	8.0	34.5	95.3	0.838	0.007	0.032
13	AVG –B2 [d]	1051.8~	680.5	8.0	34.5	95.3	0.638	0.007	0.032
13	11:07:08	1273.8	840.6	12.1	70.6	101.5	0.660	0.009	0.055
13	AVG –B1 [d]	1226.7 ,	846.6	12.1	70.6	101.5	0.860	0.009	0.055
14	11:45:38	854.9	573.6	4.0	40.7	101.6	0.671	0.005	0.048
14	AVG -02 [d]	854.9	573.6	4.0	40.7	101.6	0.671	0.005	0.046
15	12:12:25	53.8	0.0	24.9	3.0	53.3	0.000	0.465	0.055
15	12:31:25	1318.5	107.1	751.5	6.6	69.1	0.061	0.570	0.005
15	12:49:25	140.3	28.3	71.9	5.2	84.4	0.202	0.513	0.037
15	13:16:55	1514.3	150.8	860.2	5.8	71.4	0.100	0.568	0.004
15	AVG	946.2	71.6	427.1	5.1	69.6	0.096	0.529	0.025
NA	13:44:55	1521.6	113.1	863.0	4.9	87.7	0.074	0.567	0.003
16	14:23:27	1253.0	43.6	784.0	7.5	68.2	0.035	0.626	0.006
16	14:41:27	1086.4	63.4	895.0	6.8	91.4	0.058	0.824	0.006
16	14:59:42	1757.6	150.9	2030.0	6.6	128.2	0.066	1.155	0.067
18	AVG	951.9	86.0	1236.3	7.0	95.9	0.060	0.868	0.026
NA	15:08:27	1519.8	744.9	872.0	31.5	129.5	0.490	0.472	0,021
NA	16:30:57	297.0	0.0	663.0	5.2	232.1	0.000	2.300	0.018
17	15:18:27	1547.0	145.6	1890.0	4.9	135.9	0.094	0.547	0.003
17	15:36:27	1675.9	79.2	1980.0	5.2	125.2	0.047	1.181	0.003
17	15:54:27	1018.9	42.0	824.0	6.3	87.5	0.041	0.809	0.006
17	16:12:57	1362.8	64.0	1930.0	5.5	149.9	0.047	1.427	0.004
17	AVG	943.9	82.7	1656.0	5.5	124.6	0.057	0.991	0.004

[a] THC averages calculated from the full CEM data base (not just the above entries)

[b] GC/THC RATIO = (ETOH/1.42+AA/1.23+CH4)/THC * 100 where: 1.42 = Ethanol CECF
1.23 = Acetaldehyde CECF

[c] THC proportions were calculated as:ETH/THC = ppmv ethanol/ppmC THC, CH4/THC = ppmv CH4/ pmC THC,
AA/THC = ppmv acetaldehyde/ ppmC THC

[d] B1 = Burner 1. B2 = Burner 2 (Bun Oven)

NA = Not Applicable. Values were not included in the test run average,

Table 3– 17. Method 25A and Method 18 Emissions Tests Results (cont), Rear (Burner) Stacks, EPA Bakeries, Site 3 (1992).

REAR/BURNER STACK									
RUN	TIME	METHOD 25A THC RESULTS[a] (ppmC/wet)	METHOD 18 Gc RESULTS ETHANOL (ppmv/wet)	METHANE (ppmv/wet)	ACET-ALDEHYDE (ppmv/wet)	GC/THC RATIO[b] (%)	THC PROPORTIONS[c] ETH/THC RATIO	CH4/THC RATIO	AA/THC RATIO
18	11:01:49	954.6	672.2	5.7	43.2	106.2	0.704	0.006	0.045
18	10:26:09	891.8	519.0	7.9	56.8	91.4	0.582	0.009	0.064
18	AVG –B2[d]	924.4	595.6	6.6	SO.0	96.6	0.643	0.007	0.054
18	10:43:59	866.1	562.0	8.0	49.1	100.0	0.649	0.009	0.057
18	11:10:49	1011.6	1060.0	2.5	21.6	151.7	1.046	0.003	0.021
18	AVG –B1[d]	939.7	811.0	5.2	95.4	125.9	0.848	0.006	0.039
NA	11:28:39	1782.3	82.8	2050.0	3.3	121.8	0.046	1.150	0.002
19	11:46:39	793.6	23.4	1660.0	3.0	216.3	0.029	2.117	0.004
19	12:04:49	1786.6	69.0	2070.0	4.1	121.6	0.039	1.159	0.002
19	AVG	1090.2	46.2,	1875.0	9.5	169.0	0.034	1.636	003
NA	14:15:09	1126.7	27.9	1820.0	4.5	165.5	0.025	1.615	
NA	14:32:49	78.2	19.9	56.9	3.3	114.0	0.254	0.727	0.0
20	14:51:09	444.8	56.7	396.0	4.4	108.3	0.127	0.890	0.010
20	15:09:39	1635.2	230.0	2010.0	3.6	143.2	0.141	1.229	0.002
20	15:27:29	1664.6	196.0	2020.0	4.7	136.8	0.116	1.199	0
20	AVG	966.2	180.9	1475.5	4.2	129.4	0.128	1.106	0.005
NA	15:45:29	214.6	46.4	104.0	2.4	81.9	0.226	0.465	0.485
21	16:03:39	495.4	80.1	1760.0	3.5	379.1	0.162	3.553	0.007
21	16:21:59	1322.0	447.0	804.0	32.2	111.8	0.338	0.608	0.024
21	16:41:29	1202.5	187.0	881.0	4.9	95.8	0.156	0.733	0.004
21	16:58:59	964 7	54.3	834.0	5.9	95.2	0.056	0.864	0.006
21	AVG	1002.1	229.4	839.7	14.3	tot.0	0.183	0.735	0.012

[a] THC averages calculated from the full CEM data base (not just the above entries)

[b] GC/THC RATIO = (ETOH/1.42+AA/1.23+CH4)/THC * 100 where: 1.42 = Ethanol CECF
1.23 = Acetaldehyde CECF

[c] THC proportions were calculated as:ETH/THC = ppmv ethanol/ppmC THC, CH4/THC = ppmv CH4/ pmC THC,
AA/THC = ppmv acetaldehyde/ ppmC THC

[d] B1 = Burner 1. B2 = Burner 2 (Bun Oven)

NA= Not Applicable. Values were not included in the test run average.

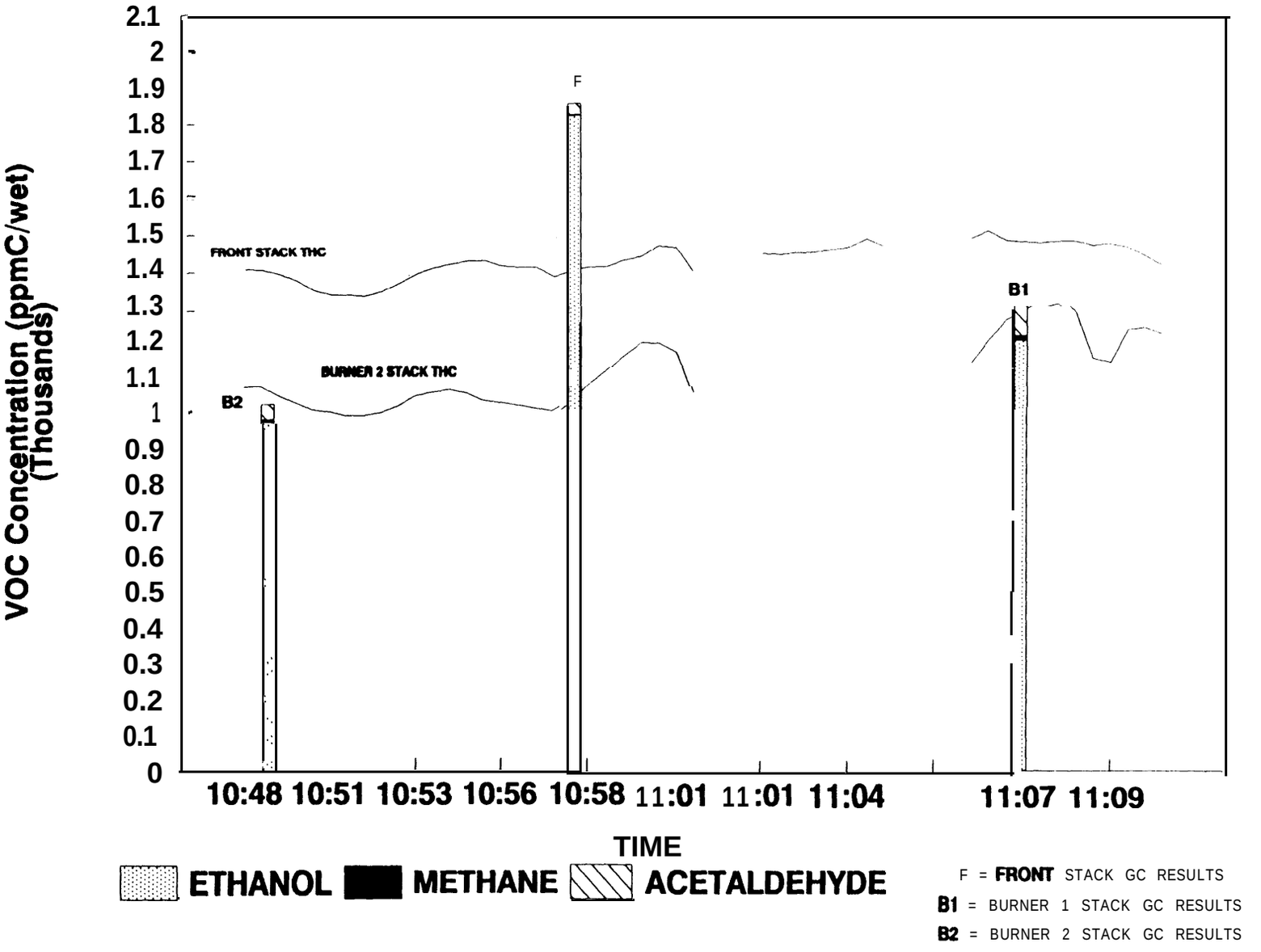

Figure 3-13. Run 13 Method 25A and Method 18 Results (adjusted to ppmC) .

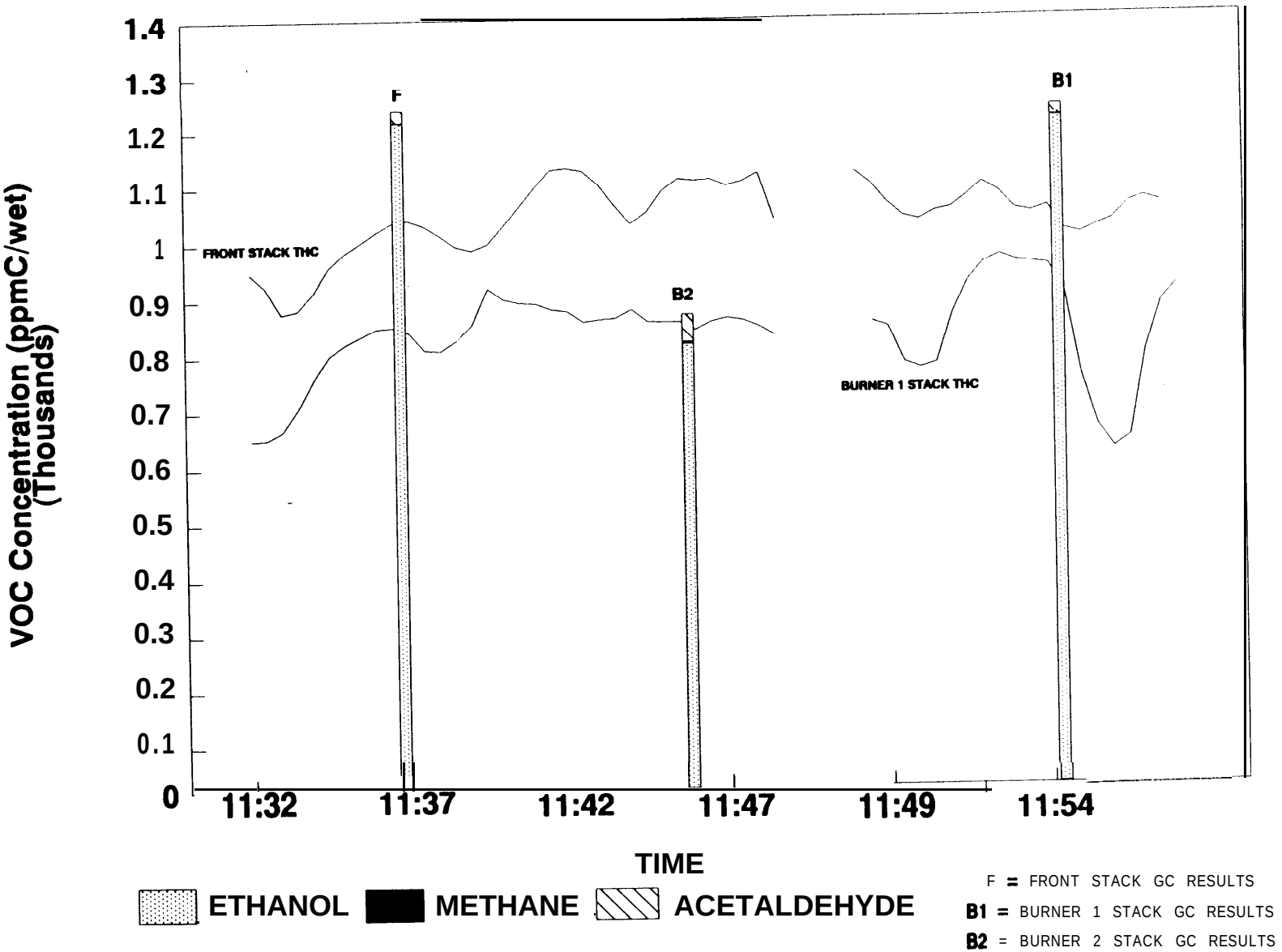

Figure 3-14. Run 14 Method 25A and Method 18 Results (adjusted to ppmC) .

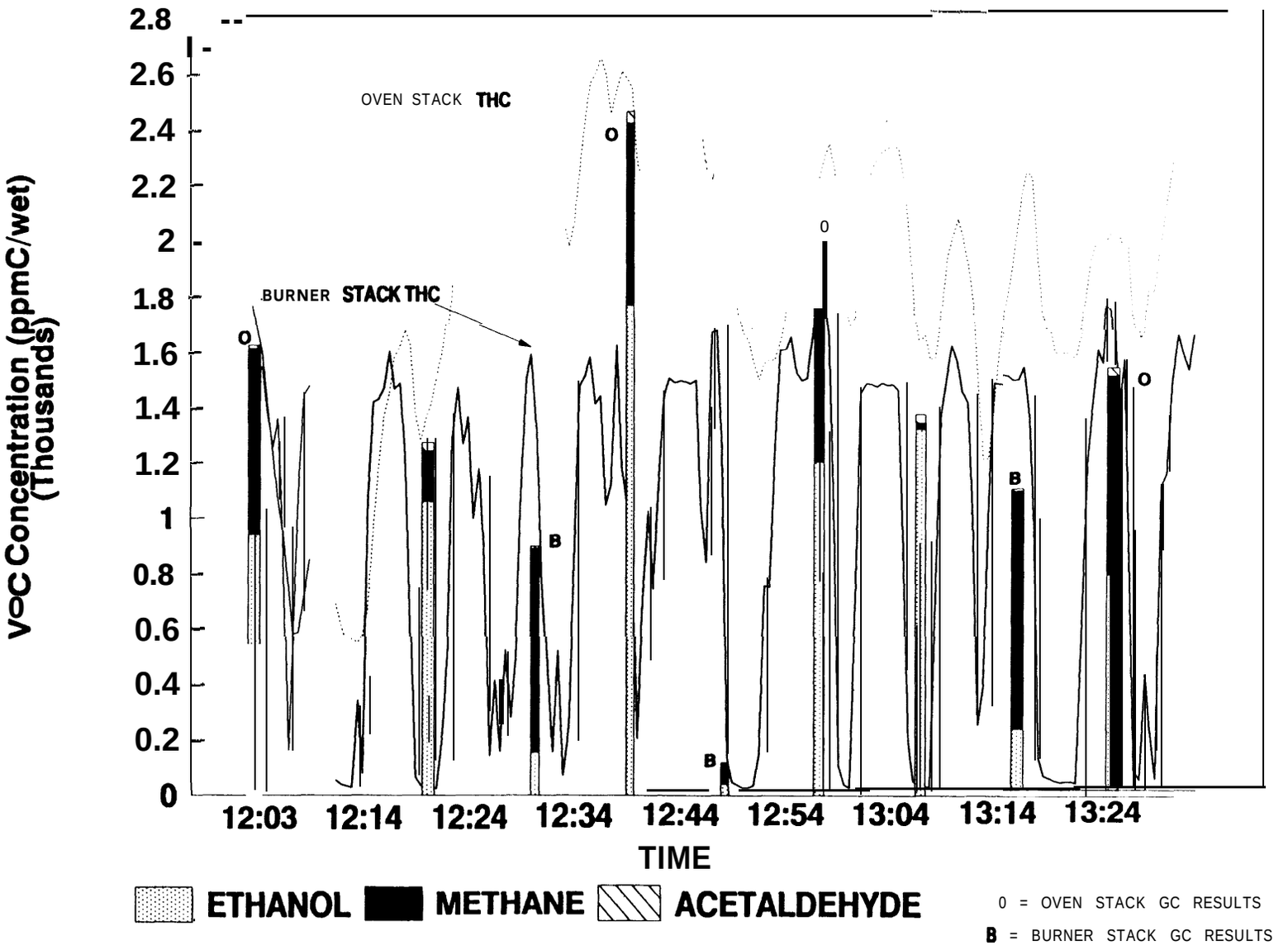

Figure 3-15. Run 15 Method 25A and Method 18 Results (adjusted to ppmC) .

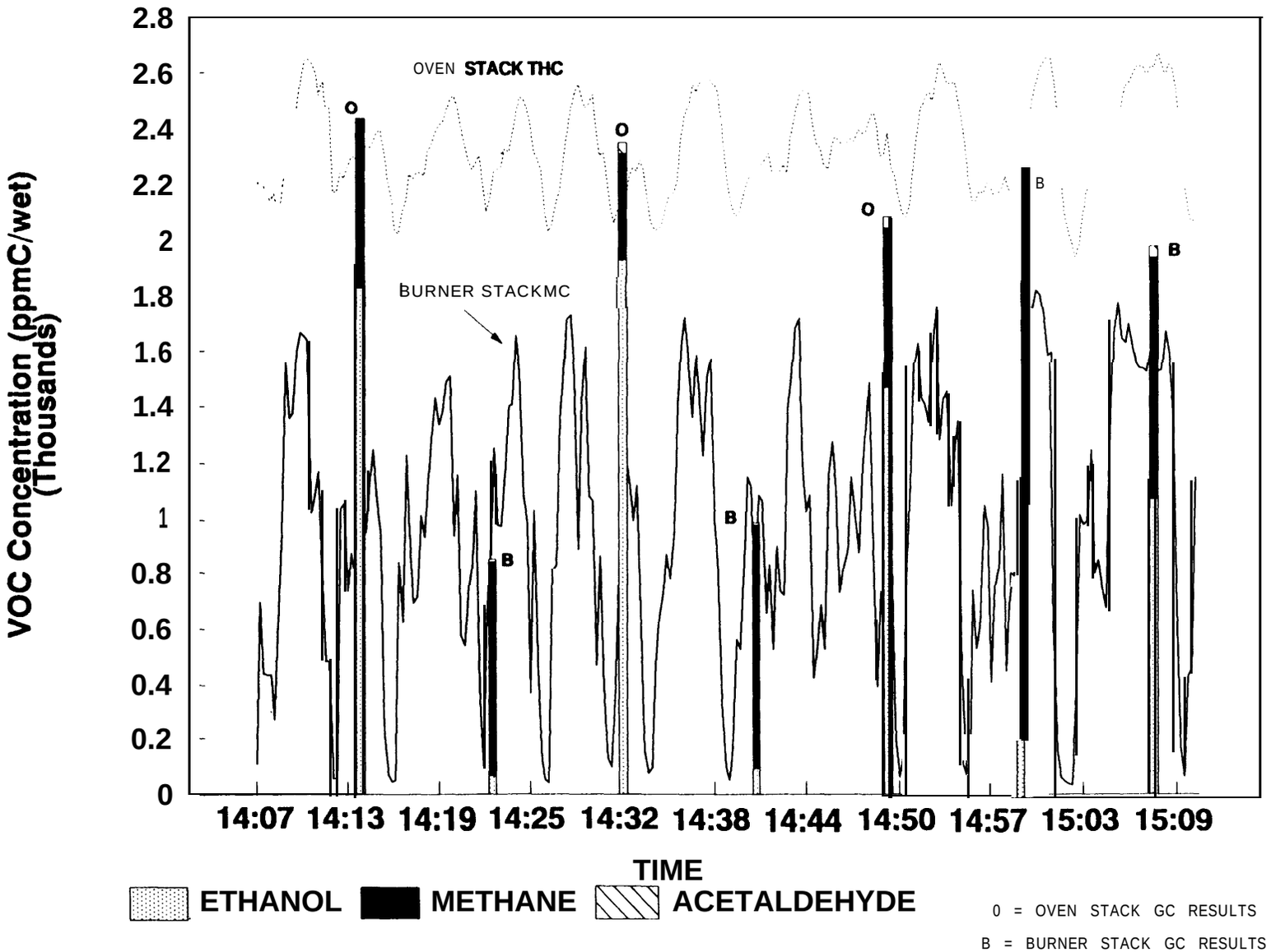

Figure 3-16. Run 16 Method 25A and Method 18 Results (adjusted to ppmC) .

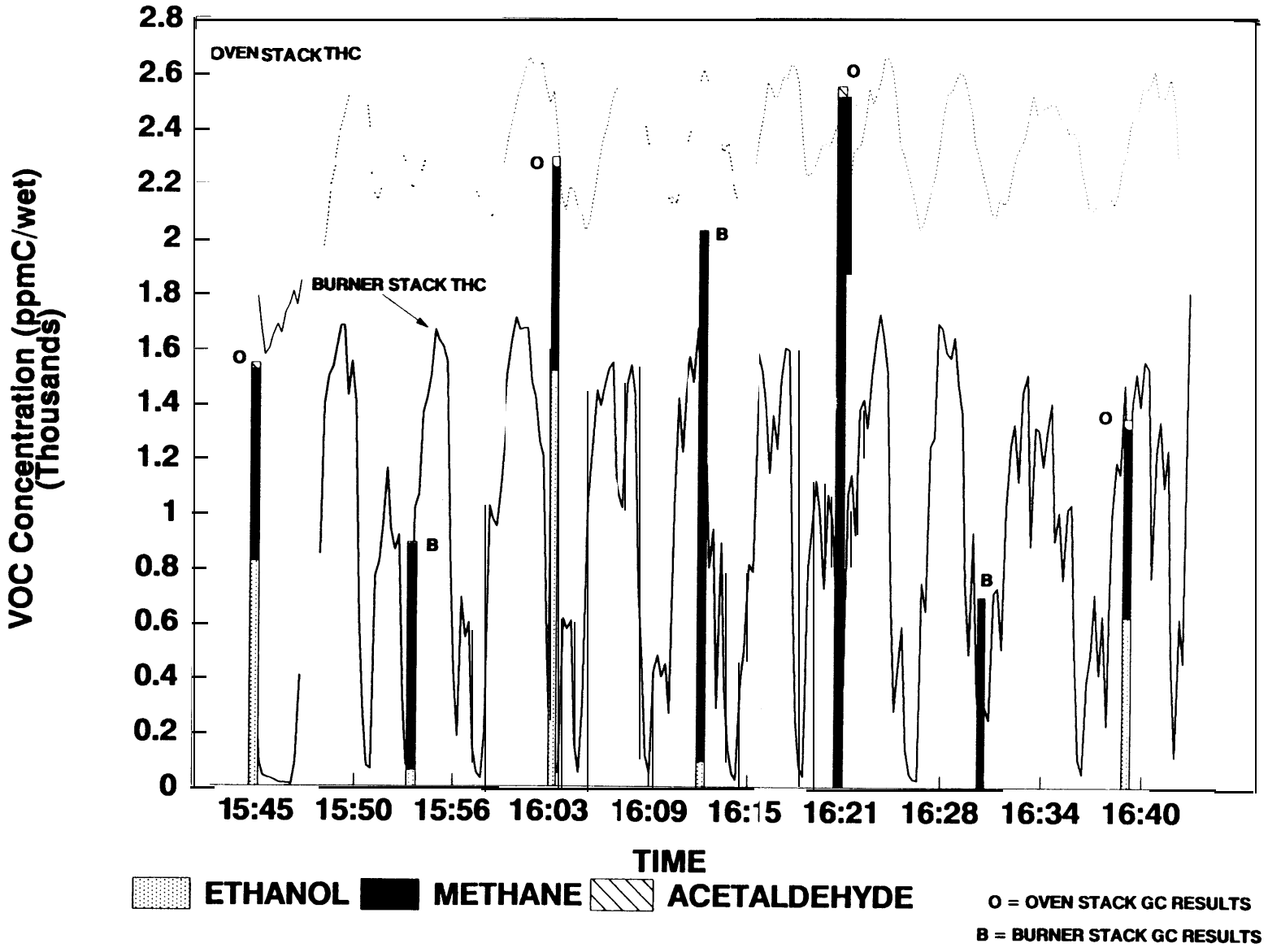

Figure 3-17. Run 17 Method 25A and Method 18 Results (adjusted to ppmC)

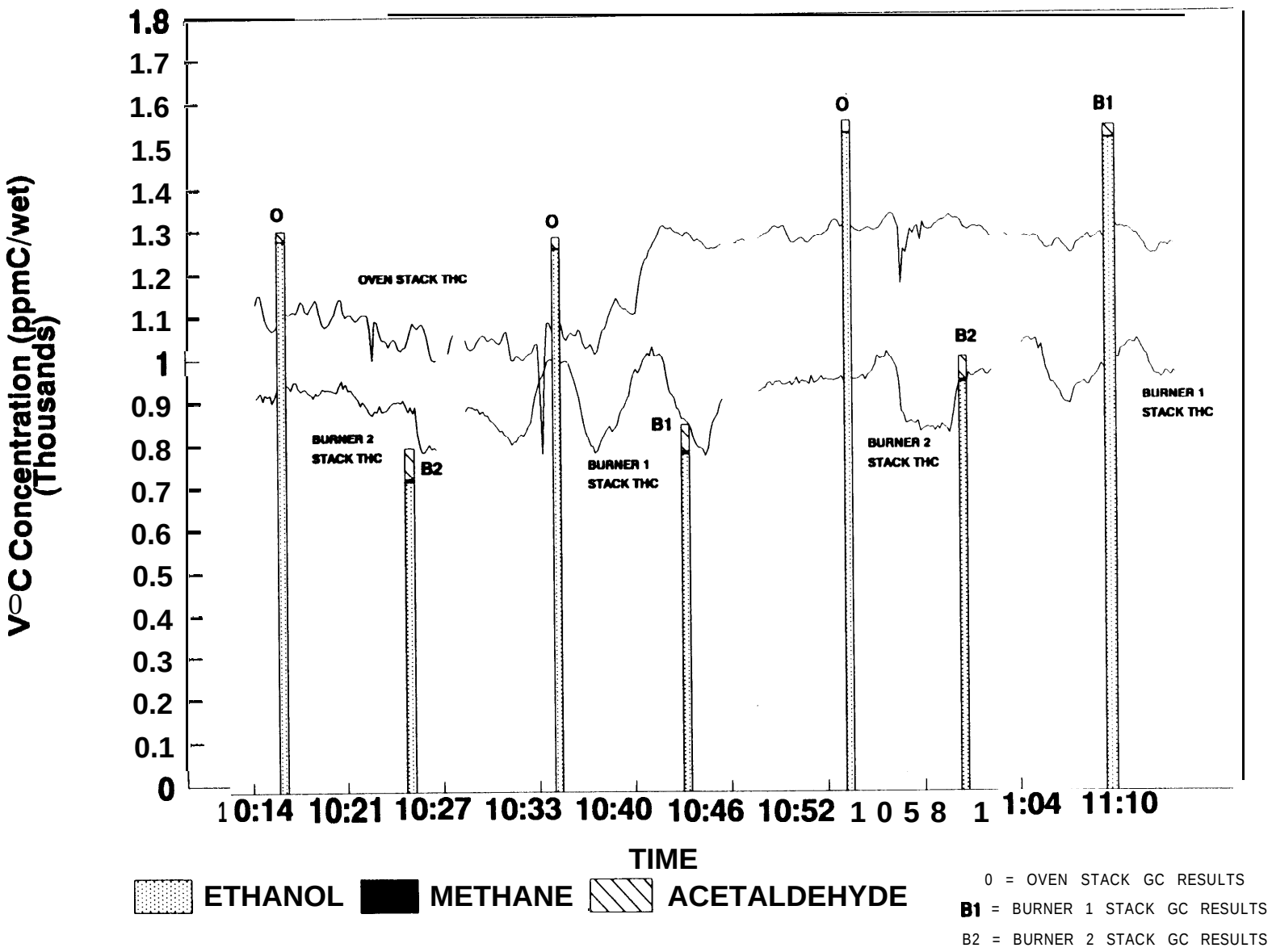

Figure 3-18. Run 18 Method 25A and Method 18 Results (adjusted to ppmC) .

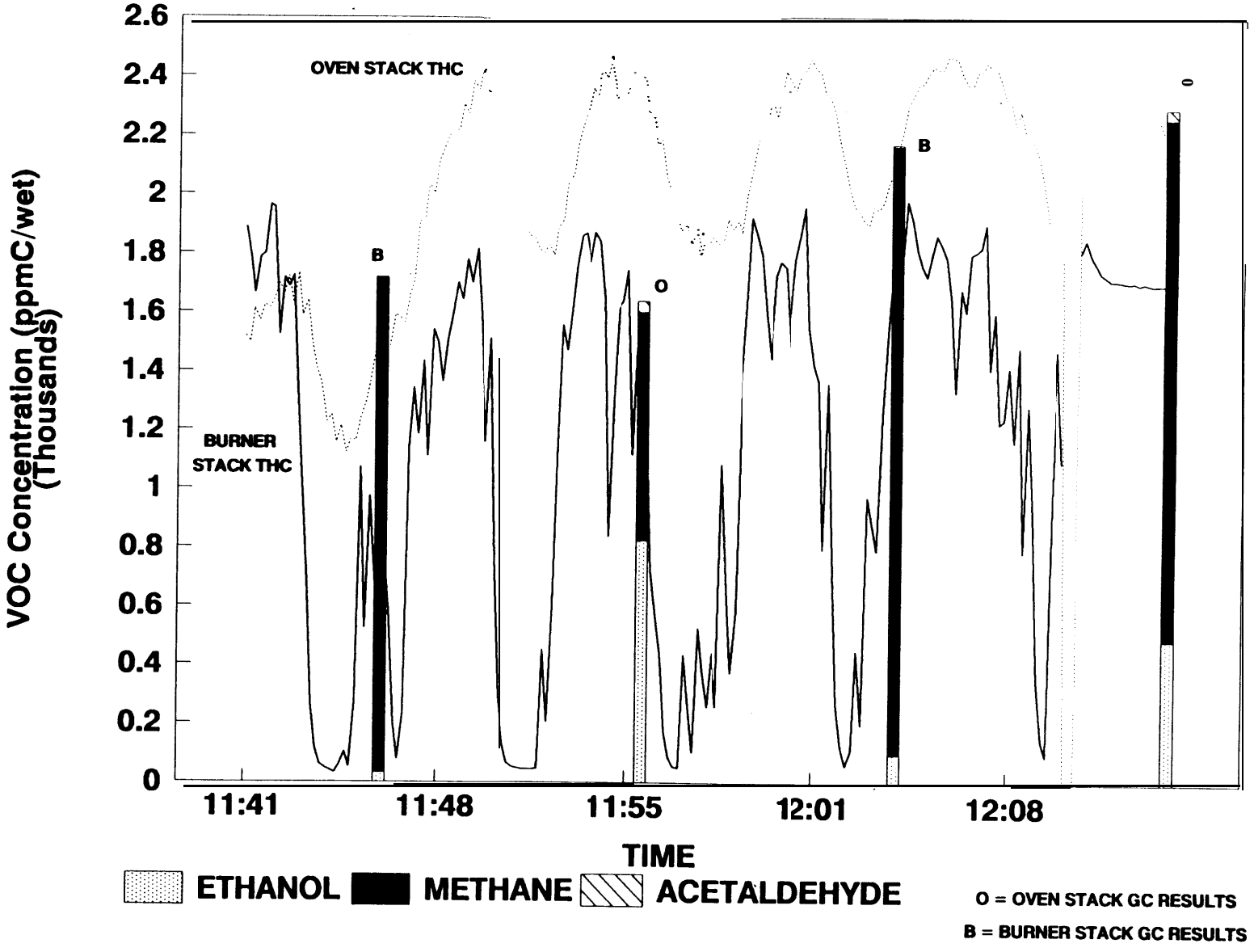

Figure 3-19. Run 19 Method 25A and Method 18 Results (adjusted to ppmC) .

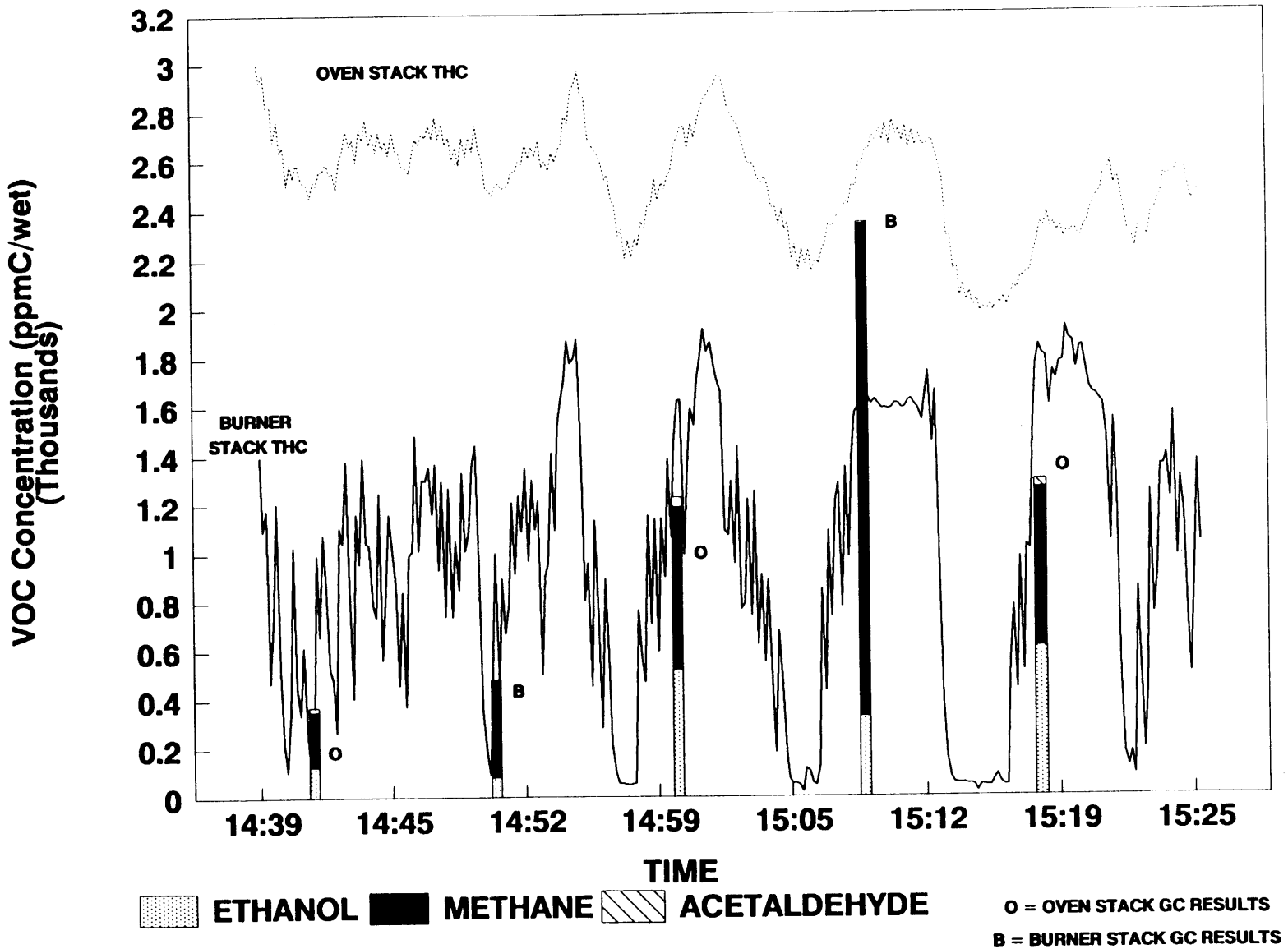

Figure 3-20. Run 20 Method 25A and Method 18 Results (adjusted to ppmC) .

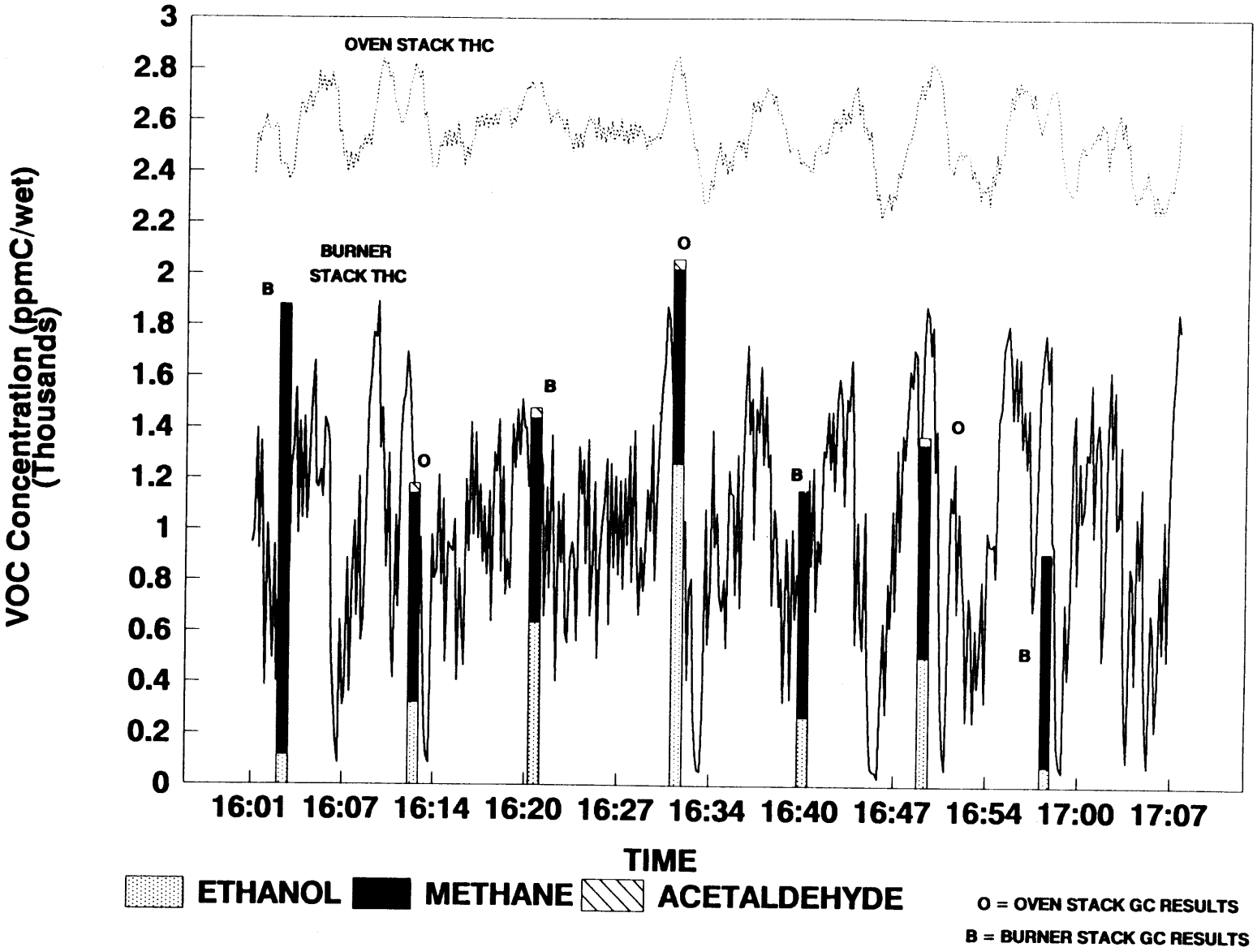

Figure 3-21. Run 21 Method 25A and Method 18 Results (adjusted to ppmC) .

3.4.5 Site 3 Stack Gas Flow Rates

Table 3-18 present the stack gas flow rates determined for the Site 2 oven stacks.

3.5 Site 4 Test Results

A large bread oven and a small bun oven were tested at Site 4. The bread oven was tested for 3 days and the bun oven was tested on the fourth day. The bread oven was a direct-fired unit with four stacks; however, one of the stacks that was located longitudinally in center of the oven was a propane burner stack strictly used for oven startup conditions. This stack was not tested and the absence of flow and high temperature in this stack was verified on-site. The other three stacks were a front, rear, and a comfort hood stack. The comfort hood stack flow measurement location met the U.S. EPA Method 1 guidelines.

The Site 4 Bun oven was a direct-fired unit with two stacks. The front stack had minimal flow similar to the exhauster stack at the Site 3 bun oven. The other unusual item with the front stack was that the gas moisture levels were approximately 30% by volume (%v). This was due to the fact that the bun oven was operated with a small amount of steam (~5 psi) injected near the front entrance to give the buns a crisp crust. All other stacks tested had moisture levels approximately 5-6%v. The flow rate and moisture content in the rear stack appeared to be typical at approximately 100 acfm and 3%v, respectively.

Table 3–18. Summary of Flue Gas Sampling Parameters EPA Bakeries, Site 3 (1992)

Run Number	Location	Stack Gas Temperature (deg F)	Barometric Pressure (in. Hg)	Stack Gas Static Pressure (in H2O)	Volumetric Flow Rate (acfm)	Volumetric Flow Rate (scfm)
Run 13	Exhauster	104	29.75	0	35.8	33.1
	Burner 1	451	29.75	−0.07	587.03	336.88
	Burner 2	486	29.75	−0.07	773	427
Run 14	Exhauster	104	29.75	0	35.8	33.1
	Burner 1	451	29.75	−0.07	587.03	336.88
	Burner 2	486	29.75	−0.07	773	427
Run 15	Oven	304	29.75	0	2,349	1,613
	Burner	401	29.75	0	822	501
Run 16	Oven	304	29.75	0	2,349	1,613
	Burner	401	29.75	0	822	501
Run 17	Oven	304	29.75	0	2,349	1,613
	Burner	401	29.75	0	822	501
Run 18	Exhauster	104	29.75	0	35.8	33.1
	Burner 1	451	29.75	−0.07	587.03	336.88
	Burner 2	486	29.75	−0.07	773	427
Run 19	Oven	304	29.75	0	2,349	1,613
	Burner	401	29.75	0	822	501
Run 20	Oven	304	29.75	0	2,349	1,613
	Burner	401	29.75	0	822	501
Run 21	Oven	304	29.75	0	2,349	1,613
	Burner	401	29.75	0	822	501

3.5.1 Site 4 Test Log

Nine emissions tests were conducted on June 29 through July 2, 1992. Runs 22 - 28 were conducted on the Bread oven and Runs 29 and 30 were conducted on the Bun oven. Table 3-19 presents a summary of the Site 4 sampling activities.

3.5.2 Site 4 VOC as Ethanol Emissions Test Results

Table 3-20 presents the VOC as ethanol test results.

3.5.3 Site 4 Ethanol and Acetaldehyde Emission Test Results

Table 3-21 presents the emission rates of ethanol and acetaldehyde.

3.5.4 Site 4 Method 25A and Method 18 Results

Tables 3-22 and 3-23 present the Method 25A and Method 18 analytical results from the oven stacks and burner stacks, respectively.

The Site 4 Method 25A and Method 18 results are presented graphically for Runs 22-30 in Figures 3-22 through 3-30, respectively. Method 18 concentrations have been corrected to ppmC for these plots.

3.5.5 Site 4 Stack Gas Flow Rates

Table 3-24 present the stack gas flow rates determined for the Site 2 oven stacks.

Table 3-19

Site 4 Bakery VOC Emissions Test Log EPA Bakeries (1992)

Run	Date	Sampling Time	Oven & Product Designation	Number of GC injections	
				Front	Rear
22	6/29/92	11:25-12:53	Bread O	5	5
23	6/29/92	13:25-14:21	Bread P	4	4
24	6/30/92	14:11-15:08	Bread Q	4	3
25	6/30/92	16:06-16:47	Bread R	3	2
26	7/01/92	10:14-11:57	Bread O	5	5
27	7/01/92	13:58-14:35	Bread O	2	2
28	7/01/92	15:04-16:18	Bread Q	4	3
29	7/02/92	10:08-14:20	Bun S	8	6
30	7/02/92	15:07-16:08	Bun T	3	3

Table 3–20. VOC Emissions Assuming 100 % Ethanol
EPA Bakeries, Site 4 (1992)

Run	Run 22			Run 23			Run 24		
Stack Location	**Front**	**Comfort**	**Rear**	**Front**	**Comfort**	**Rear**	**Front**	**Comfort**	**Rear**
THC Conc. (ppmC/wet)	3397.6	615.1	1612.0	3996.4	686.0	1981.8	3721.7	677.6	1991.1
Methane Concentrations									
Methane Conc. (ppmv/wet) [1]	1740	223.7	948.2	2090	168	972.8	1920	251	1316.7
Methane/THC Ratio	52.3	31.7	57	54.2	28.8	52.3	50.5	33.9	69.3
Methane Conc. (ppmC/wet) [2]	1776.9	195.0	918.8	2166.0	197.6	1036.5	1879.5	229.7	1379.8
VOC Emissions									
VOC Conc. (ppmC/wet) [3]	1620.7	420.1	693.2	1830.4	488.4	945.3	1842.2	447.9	611.3
VOC Conc. as Ethanol (ppmv/wet) [4]	1141.3	295.9	488.1	1289.0	344.0	665.7	1297.4	315.4	430.5
VOC Emission Rate as Ethanol (lb/hr) [4]	12.49	6.24	6.70	14.11	7.26	9.13	14.20	6.66	5.91
Total VOC Emissions as Ethanol (lbs/hr) [4]	25.431			30.499			26.760		

1 Values calculated from average methane concentrations determined from multiple GC analyses.

-- Values calculated from average Methane to THC ratios (CH4/THC) incorporating both GC and THC analyses:

2 Methane Conc. = Avg ($CH4_i/THC_i$) * (Avg THC)

3 VOC Conc. = Avg ($1 - CH4_i/THC_i$) * (Avg THC)

4 VOC Conc. as Ethanol = (VOC Conc) / 1.42 VOC Emissions as Ethanol = (VOC Conc. as Ethanol) * Flow;
where 1.42 is the empirically derived carbon equivalent correction factor

Table 3–20. VOC Emissions Assuming 100 % Ethanol (cont.)
EPA Bakeries, Site 4 (1992)

Run	Run 25			Run 26			Run 27		
Stack Location	**Front**	**Comfort**	**Rear**	**Front**	**Comfort**	**Rear**	**Front**	**Comfort**	**Rear**
THC Conc. (ppmC/wet)	2607.7	369.8	1557.3	3172.5	601.3	1584.6	3088.6	584.6	1563.9
Methane Concentrations									
Methane Conc. (ppmv/wet) [1]	1405	122	1383.3	1223.5	195	834.3	1230	234	793.5
Methane/THC Ratio	0.614	0.425	0.883	0.407	0.326	0.532	39.5	34.5	53.1
Methane Conc. (ppmC/wet) [2]	1601.1	157.2	1375.1	1291.2	196.0	843.0	1220.0	201.7	830.4
VOC Emissions									
VOC Conc. (ppmC/wet) [3]	1006.6	212.6	182.2	1881.3	405.3	741.6	1868.6	382.9	733.5
VOC Conc. as Ethanol (ppmv/wet) [4]	708.9	149.7	128.3	1324.9	285.4	522.2	1315.9	269.7	516.5
VOC Emission Rate as Ethanol (lb/hr) [4]	7.76	3.16	1.76	14.50	6.02	7.17	14.40	5.69	7.09
Total VOC Emissions as Ethanol (lbs/hr) [4]	12.678			27.687			27.179		

[1] Values calculated from average methane concentrations determined from multiple GC analyses.

-- Values calculated from average Methane to THC ratios (CH4/THC) incorporating both GC and THC analyses:

[2] Methane Conc. = Avg ($CH4_i / THC_i$) * (Avg THC)

[3] VOC Conc. = Avg ($1 - CH4_i / THC_i$) * (Avg THC)

[4] VOC Conc. as Ethanol = (VOC Conc) / 1.42 VOC Emissions as Ethanol = (VOC Conc. as Ethanol) * Flow;
where 1.42 is the empirically derived carbon equivalent correction factor

Table 3–20. VOC Emissions Assuming 100 % Ethanol (cont.)
EPA Bakeries, Site 4 (1992)

Run	Run 28			Run 29				Run 30			
Stack Location	Front	Comfort	Rear	Front [a]	Rear [a]	Front	Rear	Front [a]	Rear [a]	Front	Rear
THC Conc. (ppmC/wet)	3143.8	606.0	1781.4	463.8	213.3	643.0	203.8	517.6	263.1	800.8	261.6
Methane Concentrations											
Methane Conc. (ppmv/wet) [1]	1170	193	815.7	9.3	5.2	27.1	5.5	24.4	6.7	35.3	5.5
Methane/THC Ratio	0.367	0.362	0.478	0.018	0.012	0.042	0.028	0.044	0.025	0.042	0.022
Methane Conc. (ppmC/wet) [2]	1153.7	219.372	851.50	8.3484	2.5596	27.006	5.7064	22.7744	6.5775	33.633	5.7552
VOC Emissions											
VOC Conc. (ppmC/wet) [3]	1990.0	386.6	929.9	455.5	210.7	616.0	198.1	494.8	256.5	767.2	255.8
VOC Conc. as Ethanol (ppmv/wet) [4]	1401.4	272.3	654.9	320.7	148.4	433.8	139.5	348.5	180.6	540.3	180.2
VOC Emission Rate as Ethanol (lb/hr) [4]	15.34	5.75	8.99	0.24	1.83	0.33	1.72	0.26	2.22	0.41	2.22
Total VOC Emissions as Ethanol (lbs/hr) [4]	30.068			2.071		2.047		2.489		2.629	

1 Values calculated from average methane concentrations determined from multiple GC analyses.

-- Values calculated from average Methane to THC ratios (CH4/THC) incorporating both GC and THC analyses:

2 Methane Conc. = Avg $(CH4_i/THC_i)$ * (Avg THC)

3 VOC Conc. = Avg $(1 - CH4_i/THC_i)$ * (Avg THC)

4 VOC Conc. as Ethanol = (VOC Conc) / 1.42 VOC Emissions as Ethanol = (VOC Conc. as Ethanol) * Flow;
where 1.42 is the empirically derived carbon equivalent correction factor

[a] Testing was performed while steam was injected into the front of the oven.

Table 3–21. Ethanol and Acetaldehyde Emissions Test Results EPA Bakeries, Site 4 (1992)

Run	Run 22			Run 23			Run 24		
Stack Location	**Front**	**Comfort**	**Rear**	**Front**	**Comfort**	**Rear**	**Front**	**Comfort**	**Rear**
THC Conc. (ppmC/wet)	3397.6	615.1	1612.0	3996.4	686.0	1981.8	3721.7	677.6	1991.1
Ethanol Emissions									
Ethanol Conc. (ppmv/wet) [1]	1460	463	804	2030	555.5	1196	1880	386	1077
Ethanol Conc. (ppmv/wet) [2]	1498.3	396.7	796.3	2106.1	598.2	1268.4	1853.4	353.0	1132.9
Ethanol/THC Ratio	0.441	0.645	0.494	0.527	0.872	0.64	0.498	0.521	0.569
Ethanol Emission Rate (lb/hr) [1]	15.98	9.77	11.03	22.21	11.72	16.41	20.57	8.15	14.78
Ethanol Emission Rate (lb/hr) [2]	16.40	8.37	10.93	23.05	12.62	17.40	20.28	7.45	15.55
Total Ethanol Emission Rate (lbs/hr) [2]	35.696			53.075			43.278		
Acetaldehyde Emissions									
Acetaldehyde Conc. (ppmv/wet) [1]	46.80	8.80	27.70	63.00	6.25	37.00	61.90	11.60	37.60
Acetaldehyde Conc. (ppmv/wet) [2]	47.91	7.57	27.57	67.94	6.93	39.64	60.66	10.57	39.62
Acetaldehyde/THC Ratio	0.014	0.012	0.017	0.017	0.010	0.020	0.016	0.016	0.020
Acetaldehyde Emission Rate (lb/hr) [1]	0.490	0.178	0.364	0.659	0.126	0.486	0.648	0.234	0.494
Acetaldehyde Emission Rate (lb/hr) [2]	0.501	0.153	0.362	0.711	0.140	0.520	0.635	0.213	0.520
Total Acetaldehyde Emission Rate (lbs/hr) [2]	1.016			1.371			1.368		

[1] Values calculated from average concentrations determined from multiple GC analyses.

[2] Values calculated from average Ethanol/THC and Acetaldehyde/THC ratios (ETOH/THC and AA/THC) incorporating both GC and THC analyses: ETOH Conc. = Avg (ETOH $_i$ /THC $_i$) * (Avg THC): ETOH Emissions = (Avg ETOH Conc.) * Flow

AA Conc. = Avg (AA $_i$ /THC $_i$) * (Avg THC): AA Emissions = (Avg AA Conc.) * Flow

Table 3–21. Ethanol and Acetaldehyde Emissions Test Results (cont.)
EPA Bakeries, Site 4 (1992)

Run	Run 25			Run 26			Run 27		
Stack Location	Front	Comfort	Rear	Front	Comfort	Rear	Front	Comfort	Rear
THC Conc. (ppmC/wet)	2607.7	369.8	1557.3	3172.5	601.3	1584.6	3088.6	584.6	1563.9
Ethanol Emissions									
Ethanol Conc. (ppmv/wet) [1]	1145	119	533.7	1485	339	793	1300	412	650.5
Ethanol Conc. (ppmv/wet) [2]	1303.9	153.5	531.0	1205.6	371.0	817.7	1291.0	355.4	677.2
Ethanol/THC Ratio	0.500	0.415	0.341	0.380	0.617	0.516	0.418	0.608	0.433
Ethanol Emission Rate (lb/hr) [1]	12.53	2.51	7.32	16.25	7.15	10.88	14.23	8.69	8.93
Ethanol Emission Rate (lb/hr) [2]	14.27	3.24	7.29	13.19	7.83	11.22	14.13	7.50	9.29
Total Ethanol Emission Rate (lbs/hr) [2]	24.794			32.242			30.921		
Acetaldehyde Emissions									
Acetaldehyde Conc. (ppmv/wet) [1]	42.90	4.89	27.10	43.50	6.75	26.50	42.50	8.31	25.90
Acetaldehyde Conc. (ppmv/wet) [2]	48.76	6.47	26.94	46.00	6.85	26.78	42.31	7.19	27.21
Acetaldehyde/THC Ratio	0.019	0.018	0.017	0.015	0.011	0.017	0.014	0.012	0.017
Acetaldehyde Emission Rate (lb/hr) [1]	0.449	0.099	0.356	0.455	0.136	0.348	0.445	0.168	0.340
Acetaldehyde Emission Rate (lb/hr) [2]	0.510	0.131	0.354	0.482	0.138	0.351	0.443	0.145	0.357
Total Acetaldehyde Emission Rate (lbs/hr) [2]	0.995			0.971			0.945		

1 Values calculated from average concentrations determined from multiple GC analyses.

2 Values calculated from average Ethanol/THC and Acetaldehyde/THC ratios (ETOH/THC and AA/THC) incorporating both GC and THC analyses: ETOH Conc. = Avg ($ETOH_i/THC_i$) * (Avg THC): ETOH Emissions = (Avg ETOH Conc.) * Flow

AA Conc. = Avg (AA_i/THC_i) * (Avg THC): AA Emissions = (Avg AA Conc.) * Flow

Table 3–21. Ethanol and Acetaldehyde Emissions Test Results (cont.)
EPA Bakeries, Site 4 (1992)

Run	Run 28			Run 29				Run 30			
Stack Location	Front	Comfort	Rear	Front [a]	Rear [a]	Front	Rear	Front [a]	Rear [a]	Front	Rear
THC Conc. (ppmC/wet)	3143.8	606.0	1781.4	463.8	213.3	643.0	203.8	517.6	263.1	800.8	261.6
Ethanol Emissions											
Ethanol Conc. (ppmv/wet) [1]	1480	439	871.3	369	190.6	481.3	192	349.5	196	611	205
Ethanol Conc. (ppmv/wet) [2]	1443.0	500.0	917.4	352.0	162.3	475.2	200.1	348.3	192.1	580.6	212.4
Ethanol/THC Ratio	0.459	0.825	0.515	0.759	0.761	0.739	0.982	0.673	0.73	0.725	0.812
Ethanol Emission Rate (lb/hr) [1]	16.20	9.26	11.96	0.28	2.35	0.37	2.36	0.27	2.41	0.46	2.52
Ethanol Emission Rate (lb/hr) [2]	15.79	10.55	12.59	0.27	2.00	0.36	2.46	0.26	2.36	0.44	2.62
Total Ethanol Emission Rate (lbs/hr) [2]	38.930			2.266		2.825		2.629		3.056	
Acetaldehyde Emissions											
Acetaldehyde Conc. (ppmv/wet) [1]	49.80	8.65	29.10	13.50	5.72	21.90	6.02	11.80	4.93	21.90	5.28
Acetaldehyde Conc. (ppmv/wet) [2]	49.04	9.82	30.28	12.52	4.84	21.60	6.28	11.90	4.84	20.82	5.44
Acetaldehyde/THC Ratio	0.016	0.016	0.017	0.027	0.023	0.034	0.031	0.023	0.018	0.026	0.021
Acetaldehyde Emission Rate (lb/hr) [1]	0.521	0.175	0.382	0.010	0.067	0.016	0.071	0.009	0.058	0.016	0.062
Acetaldehyde Emission Rate (lb/hr) [2]	0.513	0.198	0.397	0.009	0.057	0.016	0.074	0.009	0.057	0.015	0.064
Total Acetaldehyde Emission Rate (lbs/hr) [2]	1.109			0.066		0.090		0.066		0.079	

[1] Values calculated from average concentrations determined from multiple GC analyses.

[2] Values calculated from average Ethanol/THC and Acetaldehyde/THC ratios (ETOH/THC and AA/THC) incorporating both GC and THC analyses: ETOH Conc. = Avg ($ETOH_i/THC_i$) * (Avg THC): ETOH Emissions = (Avg ETOH Conc.) * Flow

AA Conc. = Avg (AA_i/THC_i) * (Avg THC): AA Emissions = (Avg AA Conc.) * Flow

[a] Testing was performed while steam was injected into the front of the oven.

Table 3-22. Method 25A and Method 18 Emissions Tests Results, Front Stacks, EPA Bakeries, Site 4 (1992).

FRONT/OVEN STACK									
RUN	TIME	METHOD 25A THC RESULTS[a] (ppmC/wet)	METHOD 18 GC RESULTS			GC/THC RATIO [b] (%)	THC PROPORTIONS [c]		
			ETHANOL (ppmv/wet)	METHANE (ppmv/wet)	ACET-ALDEHYDE (ppmv/wet)		ETH/THC RATIO	CH4/THC RATIO	AA/THC RATIO
22	11:53:36	3213.2	1540	1510	43.1	116.7	0.479	0.470	0.013
22	12:12:06	3421.4	1380	1970	50.5	116.7	0.403	0.576	0.015
22	**AVG -F [d]**	**3397.6**	**1460.0**	**1740.0**	**46.8**	**116.7**	**0.441**	**0.523**	**0.014**
22	11:35:36	699.3	376	224	8.33	109.8	0.538	0.320	0.012
22	12:30:16	846.2	592	229	10.2	127.9	0.700	0.271	0.012
22	12:48:26	604.3	421	218	7.89	136.6	0.697	0.361	0.013
22	**AVG -C.H. [d]**	**615.1**	**463.0**	**223.7**	**8.8**	**124.8**	**0.645**	**0.317**	**0.012**
NA	14:53:28	2041.7	767	1440	22.2	125.2	0.376	0.705	0.01
NA	15:12:28	1498.6	638	261	8.54	78.6	0.426	0.174	0.006
23	13:36:38	3792.9	2030	2150	65.9	134.8	0.535	0.567	0.017
23	13:56:08	3917.8	2030	2030	61.3	127.3	0.518	0.518	0.016
23	**AVG -F**	**3996.4**	**2030.0**	**2090.0**	**63.6**	**131.1**	**0.527**	**0.542**	**0.017**
23	14:17:08	762.0	677	132	6.82	144.6	0.888	0.173	0.009
23	14:35:28	507.7	434	204	5.69	162.9	0.855	0.402	0.011
23	**AVG -C.H.**	**656.0**	**555.5**	**168.0**	**6.3**	**153.6**	**0.872**	**0.288**	**0.010**

[a] THC averages calculated from the full CEM data base (not just the above entries)

[b] GC/THC RATIO = (ETOH/1.42+AA/1.23+CH4)/THC * 100 where: 1.42 = Ethanol CECF
1.23 = Acetaldehyde CECF

[c] THC proportions were calculated as:ETH/THC = ppmv ethanol/ppmC THC, CH4/THC = ppmv CH4/ pmC THC, AA/THC = ppmv acetaldehyde/ ppmC THC

[d] F = Front Stack. CH = Comfort Hood Stack

NA = Not Applicable. Values were not used in the run averages.

Table 3-22. Method 25A and Method 18 Emissions Tests Results (cont), Front Stacks, EPA Bakeries, Site 4 (1992).

FRONT/OVEN STACK									
RUN	TIME	METHOD 25A THC RESULTS[a] (ppmC/wet)	METHOD 18 GC RESULTS ETHANOL (ppmv/wet)	METHANE (ppmv/wet)	ACET-ALDEHYDE (ppmv/wet)	GC/THC RATIO [b] (%)	THC PROPORTIONS [c] ETH/THC RATIO	CH4/THC RATIO	AA/THC RATIO
24	14:12:48	3914.0	1700	2200	66.2	120.0	0.434	0.562	0.017
24	14:30:38	3580.5	2030	1520	59	125.0	0.567	0.425	0.016
24	14:49:08	3871.5	1910	2040	60.4	124.7	0.493	0.527	0.016
24	**AVG -F [d]**	**3721.7**	**1880.0**	**1920.0**	**61.9**	**123.2**	**0.498**	**0.505**	**0.016**
24	15:07:08	740.2	386	251	11.6	109.9	0.521	0.339	0.016
24	**AVG -C.H. [d]**	**677.6**	**386**	**251**	**11.6**	**109.881**	**0.521**	**0.339**	**0.016**
NA	15:15	467.2	253	123	5.57	105	0.542	0.263	0.012
NA	15:25:18	401.6	187	157	3.66	106.3	0.466	0.391	0.009
25	16:06:38	286.8	119	122	4.89	103.6	0.415	0.425	0.017
25	**AVG C.H.**	**369.8**	**119**	**122**	**4.89**	**103.564**	**0.415**	**0.425**	**0.017**
25	16:24:58	2359.9	1230	1420	46.6	136.6	0.521	0.602	0.020
25	16:42:48	2218.6	1060	1390	39.2	132.7	0.478	0.627	0.018
25	**AVG -F**	**2607.7**	**1145.0**	**1405.0**	**42.9**	**134.6**	**0.499**	**0.614**	**0.019**
26	10:07:07	3156.1	1460	1380	46.1	111.2	0.463	0.437	0.015
26	10:26:37	2904.4	1590	964	41.8	112.7	0.547	0.332	0.014
26	11:21:17	2867.6	1500	1380	44.6	124.3	0.523	0.481	0.016
26	11:39:27	3091.2	1390	1170	41.6	103.4	0.450	0.378	0.013
26	**AVG -F**	**3172.5**	**1485.0**	**1223.5**	**43.5**	**112.9**	**0.496**	**0.407**	**0.015**
26	10:44:47	460.2	361	131	4.86	141.2	0.785	0.285	0.011
26	11:02:47	706.3	317	259	8.64	101.9	0.449	0.367	0.012
26	**AVG -C.H.**	**601.3**	**339.0**	**195.0**	**6.8**	**121.5**	**0.617**	**0.326**	**0.011**

[a] THC averages calculated from the full CEM data base (not just the above entries)

[b] GC/THC RATIO = (ETOH/1.42+AA/1.23+CH4)/THC * 100 where: 1.42 = Ethanol CECF
1.23 = Acetaldehyde CECF

[c] THC proportions were calculated as:ETH/THC = ppmv ethanol/ppmC THC, CH4/THC = ppmv CH4/ pmC THC,
AA/THC = ppmv acetaldehyde/ ppmC THC

[d] F = Front Stack. CH = Comfort Hood Stack

NA = Not Applicable. Values were not incorporated into the averages.

Table 3-22. Method 25A and Method 18 Emissions Tests Results (cont), Front Stacks, EPA Bakeries, Site 4 (1992).

FRONT/OVEN STACK									
RUN	TIME	METHOD 25A THC RESULTS[a] (ppmC/wet)	METHOD 18 GC RESULTS			GC/THC RATIO[b] (%)	THC PROPORTIONS[c]		
			ETHANOL (ppmv/wet)	METHANE (ppmv/wet)	ACET-ALDEHYDE (ppmv/wet)		ETH/THC RATIO	CH4/THC RATIO	AA/THC RATIO
27	14:03:57	3110.3	1300	1230	42.5	100.6	0.418	0.395	0.014
27	**AVG**	**3088.6**	**1300.0**	**1230.0**	**42.5**	**100.6**	**0.418**	**0.395**	**0.014**
27	14:21:57	678.0	412	234	8.31	122.3	0.608	0.345	0.012
27	**AVG -C.H.[d]**	**584.6**	**412.0**	**234.0**	**8.3**	**122.3**	**0.608**	**0.345**	**0.012**
NA	14:39:57	464.5	207	135	3.6	93.3	0.446	0.291	0.008
NA	14:57:57	2019.3	569	1130	23.3	97.4	0.282	0.560	0.012
28	15:15:57	2932.2	1350	1240	50.5	109.8	0.460	0.423	0.017
28	15:41:37	3170.4	1350	1190	48.9	99.9	0.426	0.375	0.015
28	16:08:37	3549.6	1740	1080	50	101.8	0.490	0.304	0.014
28	**AVG**	**3143.8**	**1480.0**	**1170.0**	**49.8**	**103.8**	**0.459**	**0.367**	**0.016**
28	15:59:27	533.0	439	193	8.65	155.2	0.824	0.362	0.016
28	**AVG -C.H.**		**439.0**	**193.0**	**8.7**	**155.2**	**0.824**	**0.362**	**0.016**
NA	12:30:40	228.4	170	19.4	10.9	120.1	0.744	0.085	0.048
29	10:12:19	450.7	370.9	1.4	6.4	118.9	0.823	0.003	0.014
29	12:41:00	520.1	402	15	19	117.1	0.773	0.029	0.037
29	12:51:00	544.0	388	14.9	17.8	108.0	0.713	0.027	0.033
29	14:07:30	434.5	315	5.82	10.9	107.4	0.725	0.013	0.025
29	**AVG - ON[e]**	**463.8**	**369.0**	**9.3**	**13.5**	**112.9**	**0.759**	**0.018**	**0.027**
29	13:22:20	621.1	490	27.9	21	120.7	0.789	0.045	0.034
29	13:31:20	639.2	464	26.4	22.7	111.6	0.726	0.041	0.036
29	13:49:00	698.8	490	26.9	22.1	107.3	0.701	0.038	0.032
29	**AVG - OFF**	**643.0**	**481.3**	**27.1**	**21.9**	**113.2**	**0.739**	**0.042**	**0.034**

[a] THC averages calculated from the full CEM data base (not just the above entries)

[b] GC/THC RATIO = (ETOH/1.42+AA/1.23+CH4)/THC * 100 where: 1.42 = Ethanol CECF, 1.23 = Acetaldehyde CECF

[c] THC proportions were calculated as:ETH/THC = ppmv ethanol/ppmC THC, CH4/THC = ppmv CH4/ pmC THC, AA/THC = ppmv acetaldehyde/ ppmC THC

NA = Not Applicable. Values were not incorporated into the averages.

[d] F = Front Stack. CH = Comfort Hood Stack

[e] Steam was being injected into the front of the oven (normal operation).

Table 3–22. Method 25A and Method 18 Emissions Tests Results (cont), Front Stacks, EPA Bakeries, Site 4 (1992).

FRONT/OVEN STACK									
RUN	TIME	METHOD 25A THC RESULTS[a] (ppmC/wet)	METHOD 18 GC RESULTS			GC/THC RATIO [b] (%)	THC PROPORTIONS [c]		
			ETHANOL (ppmv/wet)	METHANE (ppmv/wet)	ACET–ALDEHYDE (ppmv/wet)		ETH/THC RATIO	CH4/THC RATIO	AA/THC RATIO
NA	14:25:30	489.4	293	231	8.97	134.5	0.599	0.472	0.018
30	14:46:40	640.1	332	49.7	7.64	82.9	0.519	0.078	0.012
30	15:04:20	477.0	351	21	9.9	111.5	0.736	0.044	0.021
30	15:42:00	501.5	363	13.3	15.6	109.3	0.724	0.027	0.031
30	15:59:50	492.7	352	13.7	14.1	107.8	0.715	0.028	0.029
30	**AVG – ON [d]**	**517.6**	**349.5**	**24.4**	**11.8**	**102.6**	**0.673**	**0.044**	**0.023**
30	15:22:20	842.2	611	35.3	21.9	110.4	0.725	0.042	0.026
30	**AVG – OFF**	**800.6**	**611.0**	**35.3**	**21.9**	**110.4**	**0.725**	**0.042**	**0.026**

[a] THC averages calculated from the full CEM data base (not just the above entries)

[b] GC/THC RATIO = (ETOH/1.42+AA/1.23+CH4)/THC * 100 where: 1.42 = Ethanol CECF
1.23 = Acetaldehyde CECF

[c] THC proportions were calculated as:ETH/THC = ppmv ethanol/ppmC THC, CH4/THC = ppmv CH4/ pmC THC,
AA/THC = ppmv acetaldehyde/ ppmC THC

NA = Not Applicable. Values were not incorporated into the averages.

[d] Steam was being injected into the front of the oven (normal operation).

Table 3-23. Method 25A and Method 18 Emissions Tests Results (cont). Rear Stacks, EPA Bakeries, Site 4 (1992).

REAR/BURNER STACK									
RUN	TIME	METHOD 25A THC RESULTS[a] (ppmC/wet)	METHOD 18 GC RESULTS			GC/THC RATIO [b] (%)	THC PROPORTIONS [c]		
			ETHANOL (ppmv/wet)	METHANE (ppmv/wet)	ACET-ALDEHYDE (ppmv/wet)		ETH/THC RATIO	CH4/THC RATIO	AA/THC RATIO
22	11:27:06	1375.5	678.0	597	28.2	115.9	0.493	0.434	0.000
22	11:44:36	1619.8	716.0	754	28.7	111.5	0.442	0.465	0.018
22	12:03:06	1744.4	933.0	1320	29.1	153.7	0.535	0.757	0.017
22	12:20:56	1645.0	1040.0	790	27	139.8	0.632	0.480	0.016
22	12:39:06	1796.0	657.0	1280	25.7	125.0	0.366	0.713	0.01
22	**AVG**	**1612.0**	**804.8**	**948.2**	**27.7**	**129.2**	**0.494**	**0.570**	**0.016**
NA	12:57:16	1944.0	557.0	1450	22.2	116.7	0.287	0.746	0.011
NA	14:44:28	1227.8	421.0	1250	14.3	151.9	0.343	1.018	0.012
NA	15:02:48	1358.7	603.0	831	13.3	125.4	0.444	0.612	0.010
23	13:26:58	1830.3	1020.0	806	42.2	126.0	0.557	0.440	0.023
23	13:45:48	2028.6	1290.0	1280	38.2	155.7	0.636	0.631	0.019
23	14:07:48	1975.4	1660.0	1040	34.8	174.1	0.840	0.526	0.018
23	14:26:28	1545.1	814.0	765	32.6	126.9	0.527	0.495	0.02
23	**AVG**	**1981.8**	**1196.0**	**972.8**	**37.0**	**145.7**	**0.640**	**0.523**	**0.02**

[a] THC averages calculated from the full CEM data base (not just the above entries)

[b] GC/THC RATIO = (ETOH/1.42+AA/1.23+CH4)/THC * 100 where: 1.42 = Ethanol CECF
1.23 = Acetaldehyde CECF

[c] THC proportions were calculated as:ETH/THC = ppmv ethanol/ppmC THC, CH4/THC = ppmv CH4/ pmC THC,
AA/THC = ppmv acetaldehyde/ ppmC THC

NA = Not Applicable Values were not incorporated into the averages.

Table 3-23. Method 25A and Method 18 Emissions Tests Results (cont), Rear Stacks, EPA Bakeries, Site 4 (1992).

REAR/BURNER STACK									
RUN	TIME	METHOD 25A THC RESULTS[a] (ppmC/wet)	METHOD 18 GC RESULTS			GC/THC RATIO [b] (%)	THC PROPORTIONS [c]		
			ETHANOL (ppmv/wet)	METHANE (ppmv/wet)	ACET-ALDEHYDE (ppmv/wet)		ETH/THC RATIO	CH4/THC RATIO	AA/THC RATIO
24	14:21:48	1968.0	911.0	1480	38.6	143.3	0.463	0.752	0.020
24	14:40:08	1936.4	1180.0	1230	36.9	152.4	0.609	0.635	0.019
24	14:58:18	1791.3	1140.0	1240	37.4	162.2	0.636	0.692	0.021
24	**AVG**	**1991.1**	**1077.0**	**1316.7**	**37.6**	**152.6**	**0.570**	**0.693**	**0.020**
25	16:15:28	1601.3	544.0	1400	30	138.0	0.340	0.874	0.019
25	16:33:58	1622.8	539.0	1380	26.8	134.2	0.332	0.850	0.017
25	16:51:48	1480.8	518.0	1370	24.6	144.2	0.350	0.925	0.017
25	**AVG**	**1557.3**	**533.7**	**1383.3**	**27.1**	**138.6**	**0.341**	**0.883**	**0.017**
26	10:16:27	1767.3	764.0	801	27.8	108.6	0.432	0.453	0.016
26	10:35:37	1517.9	900.0	835	28.2	141.5	0.593	0.550	0.019
26	10:53:47	1744.9	562.0	936	25.7	101.2	0.322	0.536	0.015
26	11:11:57	1615.8	573.0	909	26.6	108.6	0.355	0.563	0.016
26	11:30:27	1414.7	1060.0	731	26.2	160.3	0.749	0.517	0.019
26	11:49:27	1393.1	900.0	794	24.4	150.9	0.646	0.570	0.018
26	**AVG**	**1584.6**	**793.2**	**884.3**	**26.5**	**128.5**	**0.516**	**0.532**	**0.017**

[a] THC averages calculated from the full CEM data base (not just the above entries)

[b] GC/THC RATIO = (ETOH/1.42+AA/1.23+CH4)/THC * 100 where: 1.42 = Ethanol CECF
1.23 = Acetaldehyde CECF

[c] THC proportions were calculated as:ETH/THC = ppmv ethanol/ppmC THC, CH4/THC = ppmv CH4/ pmC THC,
AA/THC = ppmv acetaldehyde/ ppmC THC

Table 3-23. Method 25A and Method 18 Emissions Tests Results (cont), Rear Stacks, EPA Bakeries, Site 4 (1992).

REAR/BURNER STACK									
RUN	TIME	METHOD 25A THC RESULTS[a] (ppmC/wet)	METHOD 18 GC RESULTS			GC/THC RATIO [b] (%)	THC PROPORTIONS [c]		
			ETHANOL (ppmv/wet)	METHANE (ppmv/wet)	ACET-ALDEHYDE (ppmv/wet)		ETH/THC RATIO	CH4/THC RATIO	AA/THC RATIO
	14:12:57	1535.8	782.0	788	26.4	125.7	0.509	0.513	0.017
27	14:30:57	1454.0	519.0	799	25.4	107.8	0.357	0.550	0.017
27	**AVG**	**1563.9**	**650.5**	**793.5**	**25.9**	**116.8**	**0.433**	**0.531**	**0.017**
NA	14:48:57	1303.2	321.0	1000	13.1	112.9	0.246	0.767	0.010
28	15:06:57	1765.3	698.0	884	30.1	108.3	0.395	0.501	0.017
28	15:32:37	1491.8	886.0	688	23.9	132.4	0.594	0.461	0.016
28	15:50:37	1851.0	1030.0	875	33.3	126.5	0.556	0.473	0.018
28	**AVG**	**1781.4**	**871.3**	**815.7**	**29.1**	**123.1**	**0.515**	**0.478**	**0.017**
NA	12:22:00	221.4	157.0	5.75	6.56	106.9	0.709	0.026	0.030
29	10:21:19	230.6	193.4	-1.7	3.1	120.0	0.839	-0.008	0.013
29	13:00:00	240.8	167.0	6.5	6.02	104.3	0.694	0.027	0.025
29	13:58:00	283.3	247.0	6.55	7.11	129.2	0.872	0.023	0.025
29	14:16:30	256.4	179.0	6.97	6.64	105.0	0.698	0.027	0.026
29	14:34:20	237.4	167.0	7.76	5.75	106.1	0.703	0.033	0.024
29	**AVG - ON [d]**	**213.3**	**190.7**	**5.2**	**5.7**	**112.9**	**0.761**	**0.020**	**0.023**
29	13:40:10	195.5	192.0	5.53	6.02	146.1	0.982	0.028	0.031
29	**AVG - OFF**	**203.8**	**192.0**	**5.5**	**6.0**	**146.1**	**0.982**	**0.028**	**0.031**

[a] THC averages calculated from the full CEM data base (not just the above entries)

[b] GC/THC RATIO = (ETOH/1.42+AA/1.23+CH4)/THC * 100 where: 1.42 = Ethanol CECF
1.23 = Acetaldehyde CECF

[c] THC proportions were calculated as:ETH/THC = ppmv ethanol/ppmC THC, CH4/THC = ppmv CH4/ pmC THC, AA/THC = ppmv acetaldehyde/ ppmC THC

[d] Steam was being injected into the front of the oven (normal operation).

NA = Not Applicable. Values were not incorporated into the averages.

Table 3-23. Method 25A and Method 18 Emissions Tests Results (cont), Rear Stacks, EPA Bakeries, Site 4 (1992).

REAR/BURNER STACK									
RUN	TIME	METHOD 25A THC RESULTS[a] (ppmC/wet)	METHOD 18 GC RESULTS			GC/THC RATIO [b] (%)	THC PROPORTIONS [c]		
			ETHANOL (ppmv/wet)	METHANE (ppmv/wet)	ACET-ALDEHYDE (ppmv/wet)		ETH/THC RATIO	CH4/THC RATIO	AA/THC RATIO
30	15:51:00	268.4	196.0	6.7	4.93	108.4	0.730	0.025	0.018
30	**AVG – ON [d]**	**263.1**	**196.0**	**6.7**	**4.9**	**108.4**	**0.730**	**0.025**	**0.018**
30	15:13:30	241.9	200.0	5.6	4.44	122.0	0.827	0.023	0.018
30	15:31:00	262.6	209.0	5.46	6.12	117.9	0.796	0.021	0.023
30	**AVG – OFF**	**261.6**	**204.5**	**5.5**	**5.3**	**120.0**	**0.811**	**0.022**	**0.021**

[a] THC averages calculated from the full CEM data base (not just the above entries)

[b] GC/THC RATIO = (ETOH/1.42+AA/1.23+CH4)/THC * 100 where: 1.42 = Ethanol CECF
1.23 = Acetaldehyde CECF

[c] THC proportions were calculated as:ETH/THC = ppmv ethanol/ppmC THC, CH4/THC = ppmv CH4/ pmC THC, AA/THC = ppmv acetaldehyde/ ppmC THC

[d] Steam was being injected into the front of the oven (normal operation).

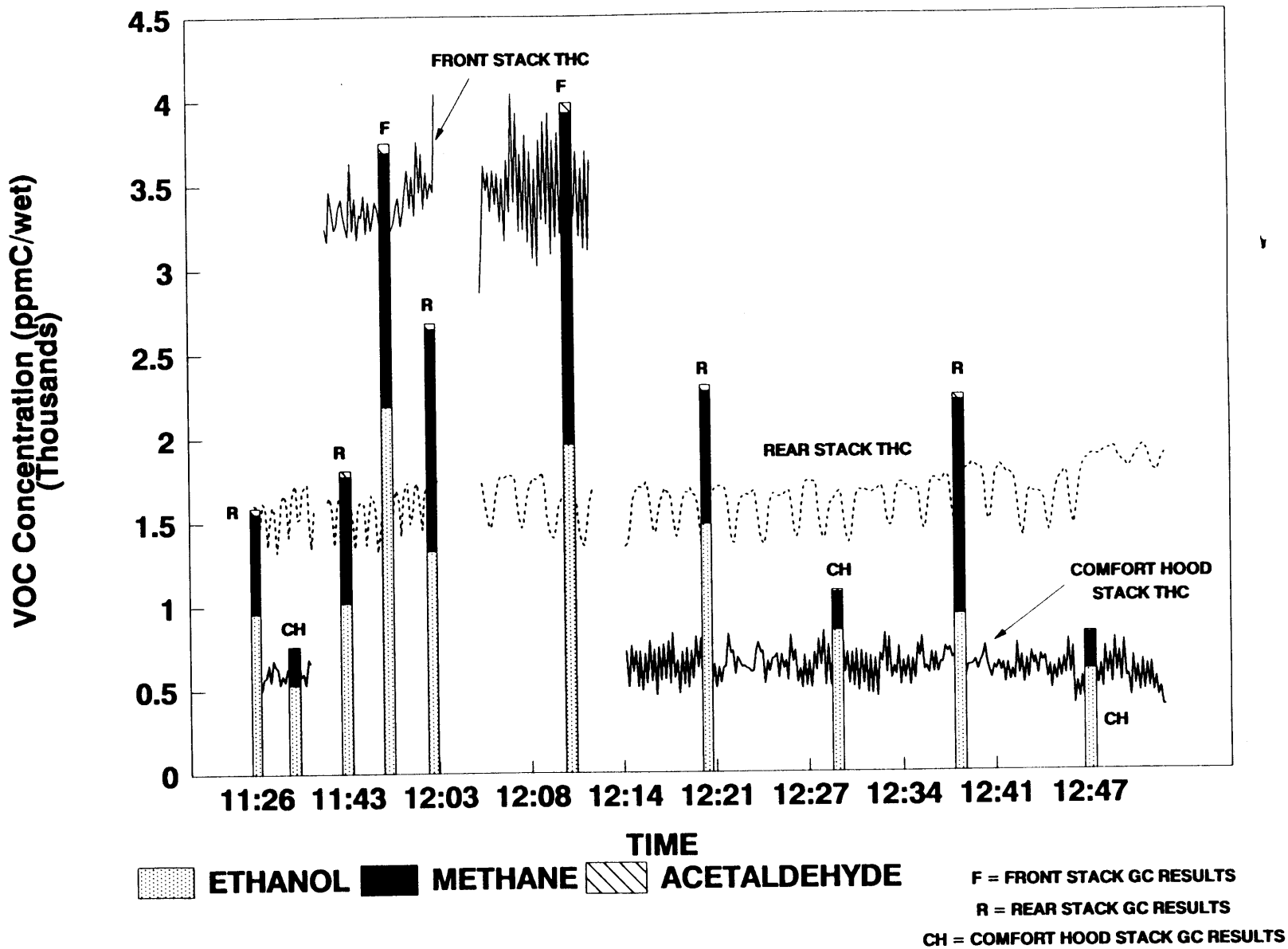

Figure 3-22. Run 22 Method 25A and Method 18 Results (adjusted to ppmC) .

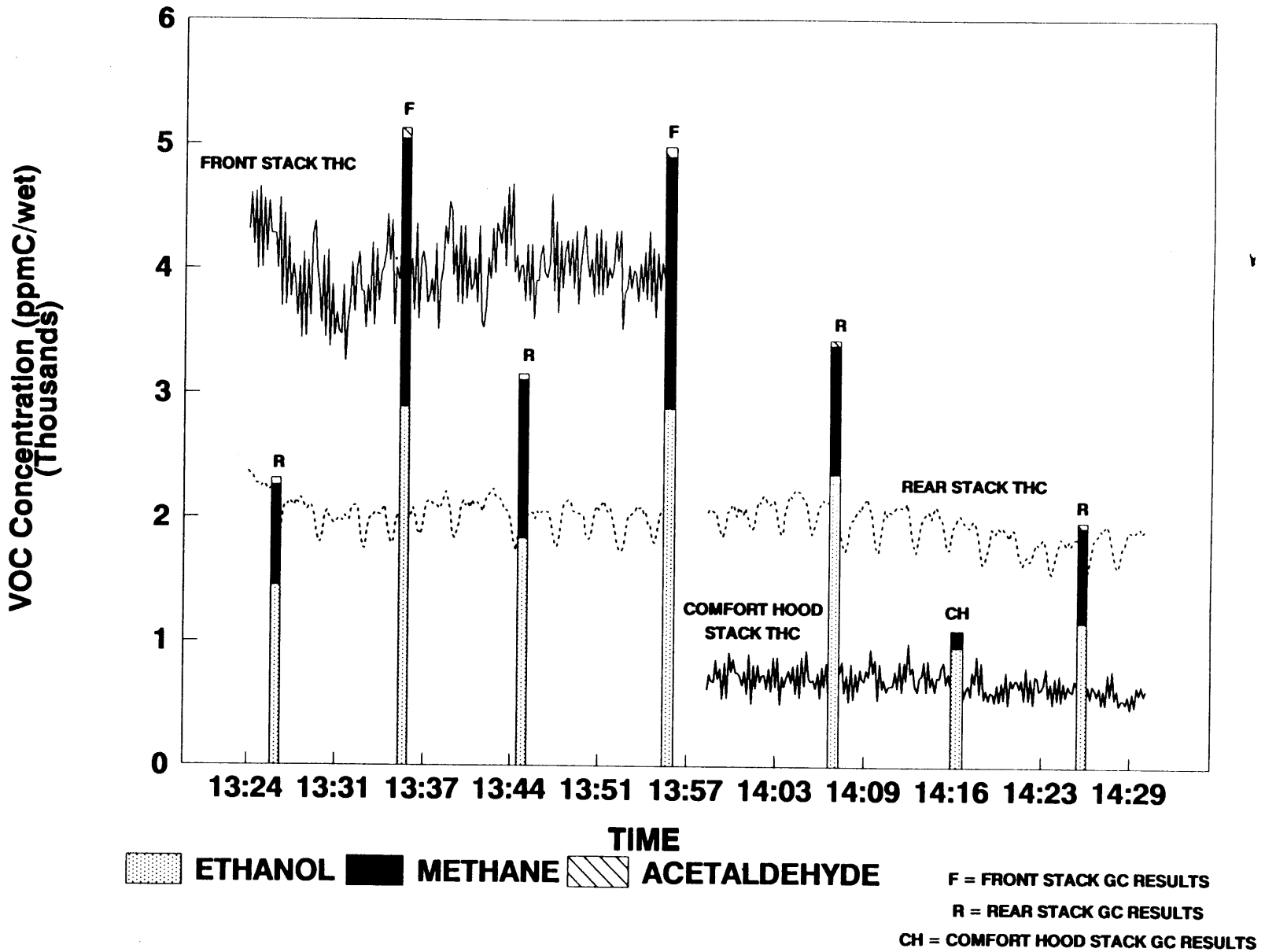

Figure 3-23. Run 23 Method 25A and Method 18 Results (adjusted to ppmC) .

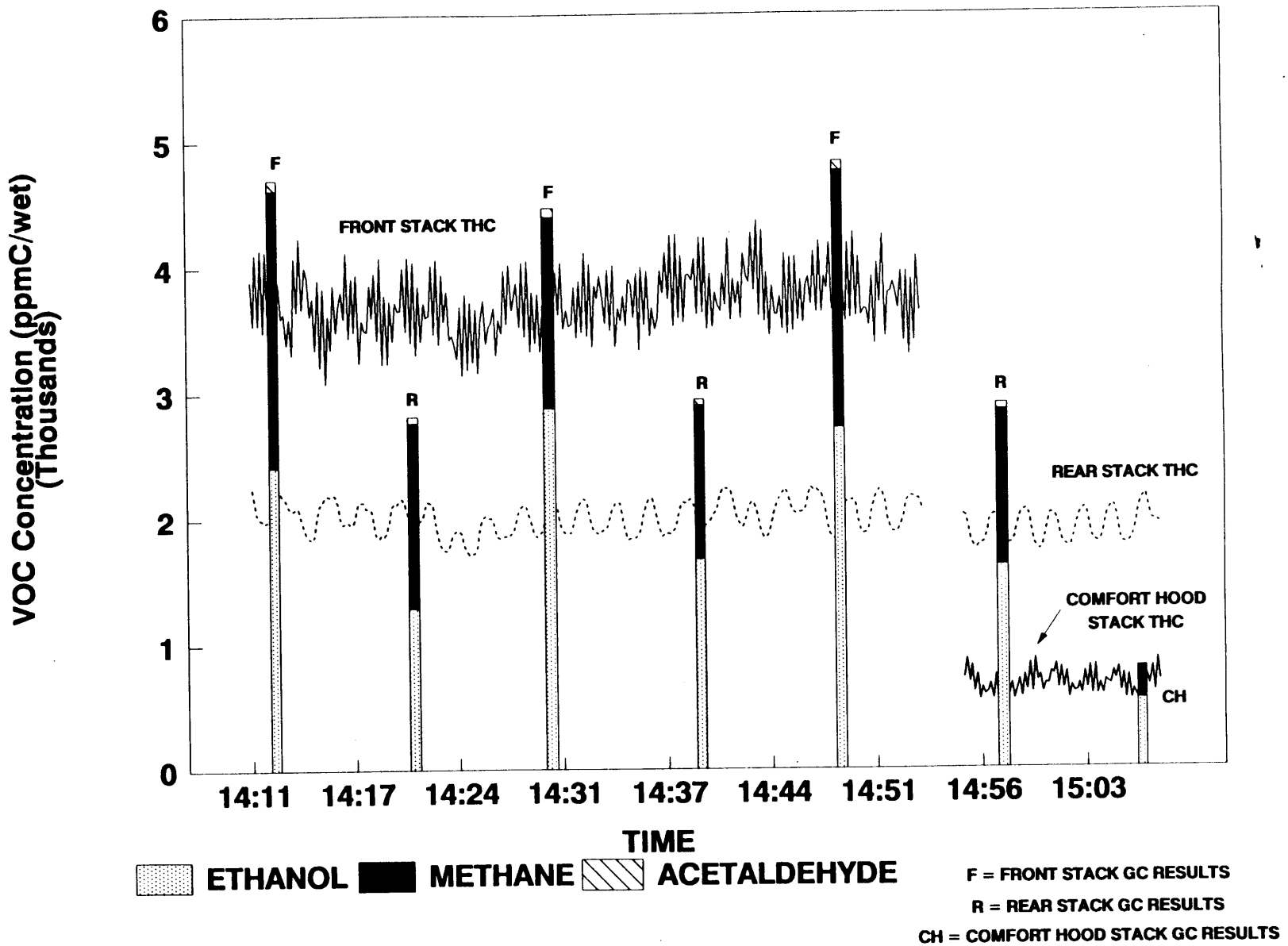

Figure 3-24. Run 24 Method 25A and Method 18 Results (adjusted to ppmC) .

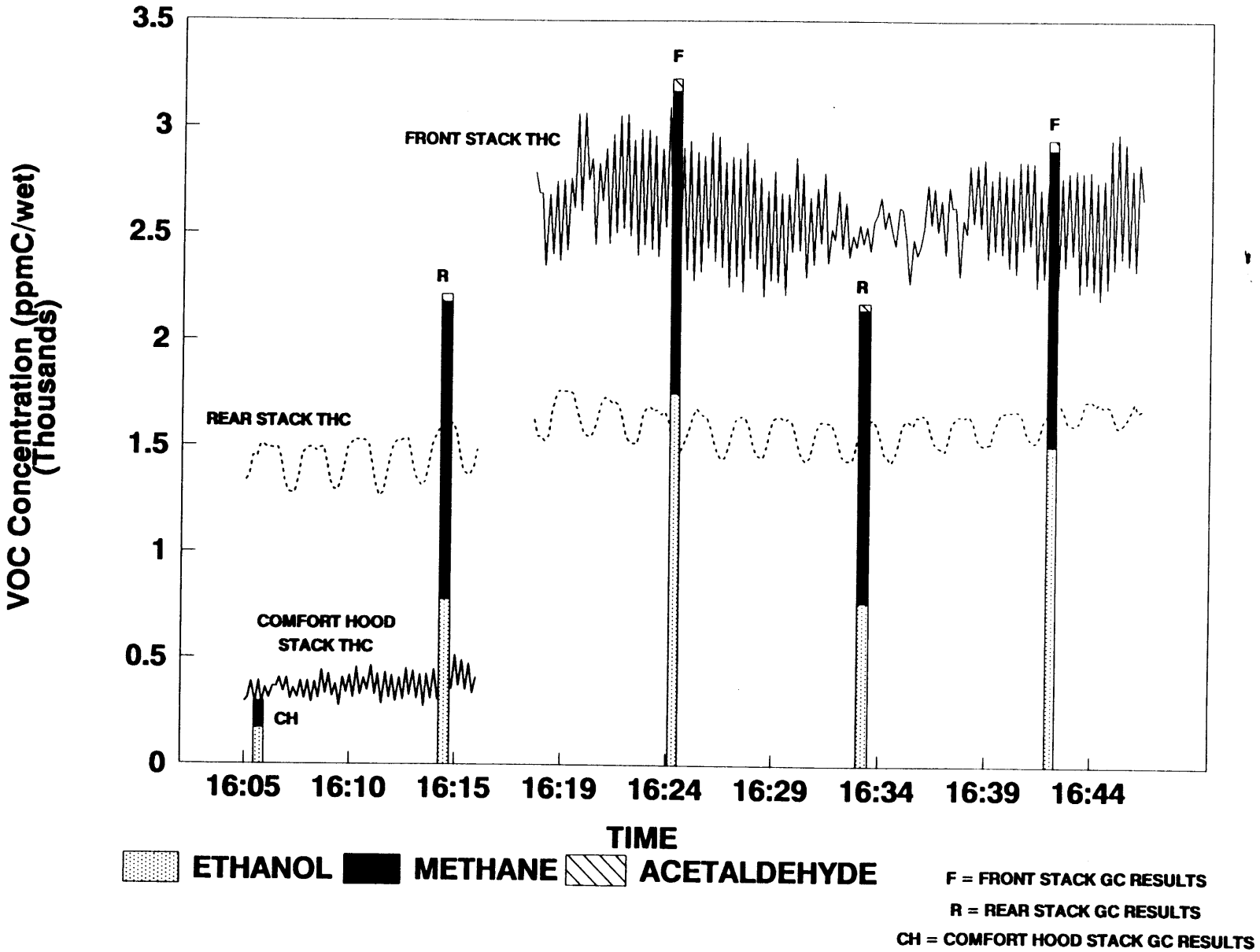

Figure 3-25. Run 25 Method 25A and Method 18 Results (adjusted to ppmC) .

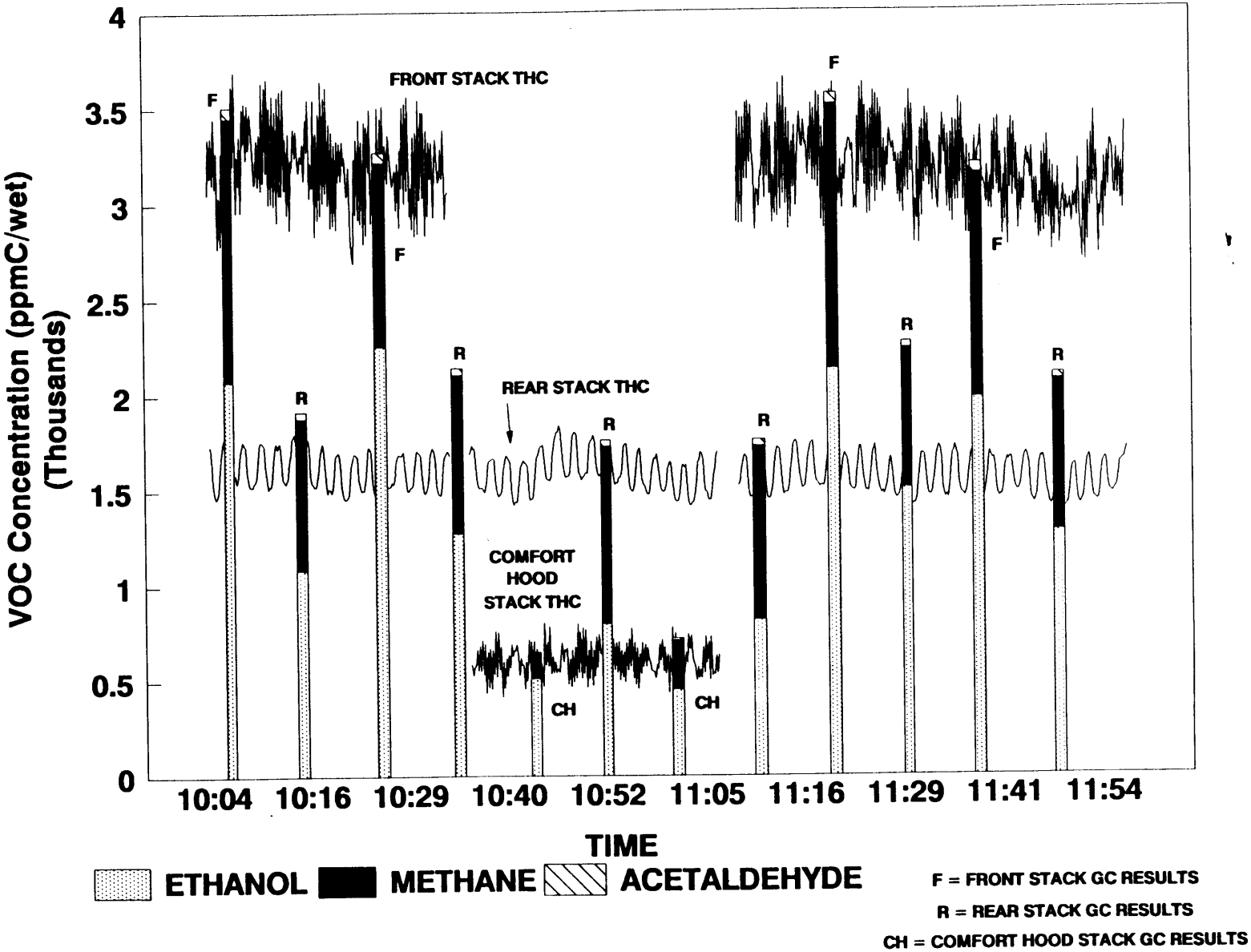

Figure 3-26. Run 26 Method 25A and Method 18 Results (adjusted to ppmC) .

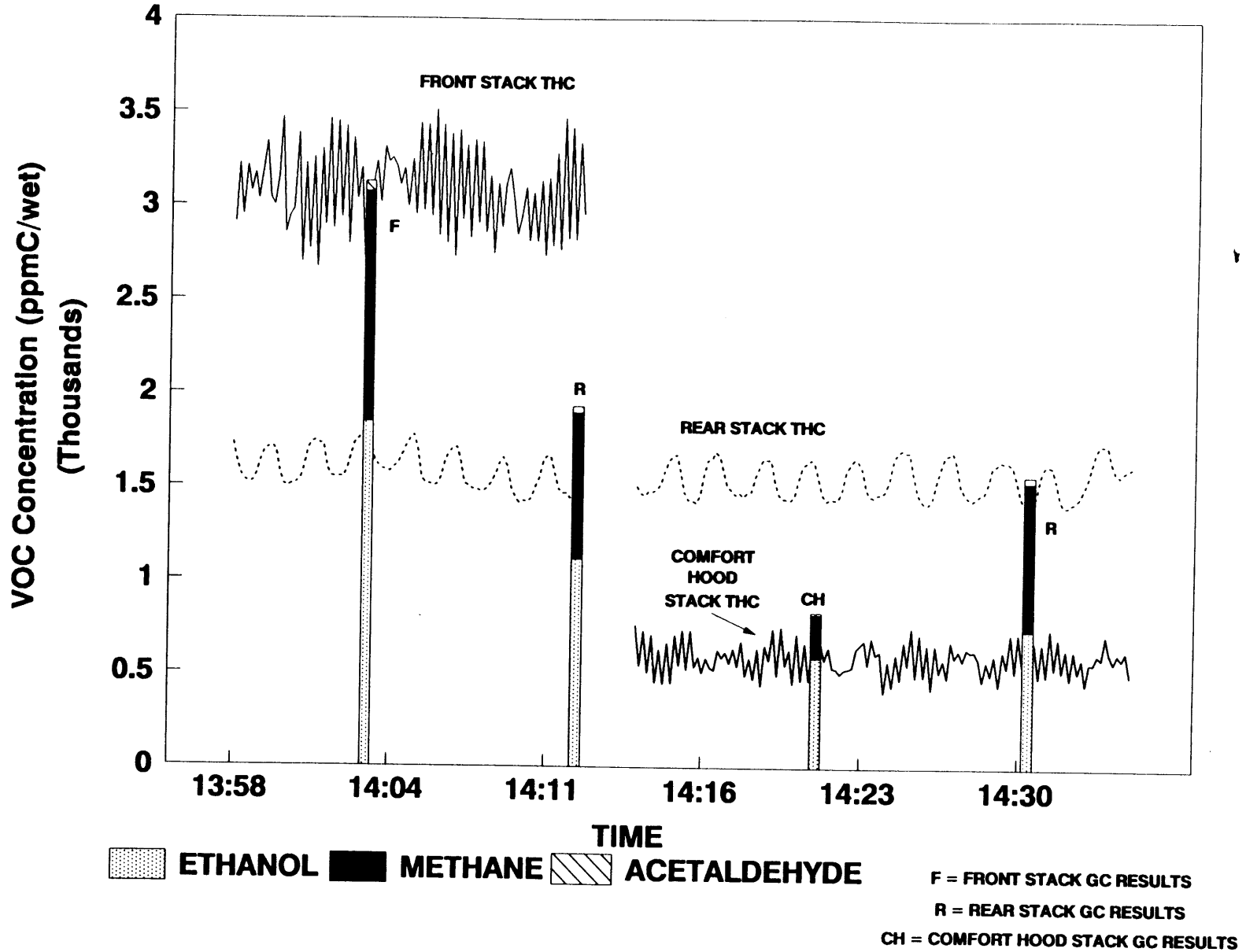

Figure 3-27. Run 27 Method 25A and Method 18 Results (adjusted to ppmC) .

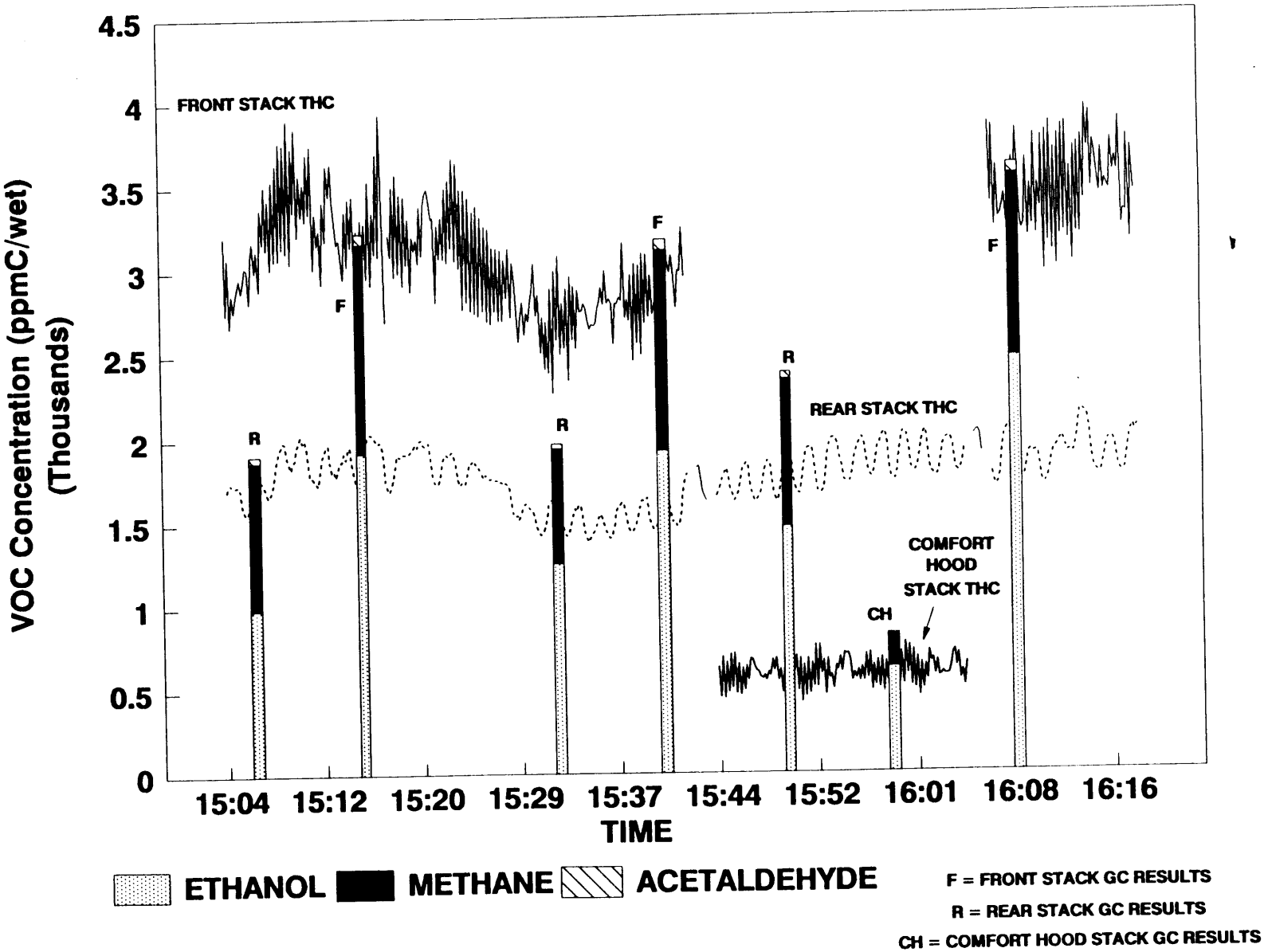

Figure 3-28. Run 28 Method 25A and Method 18 Results (adjusted to ppmC) .

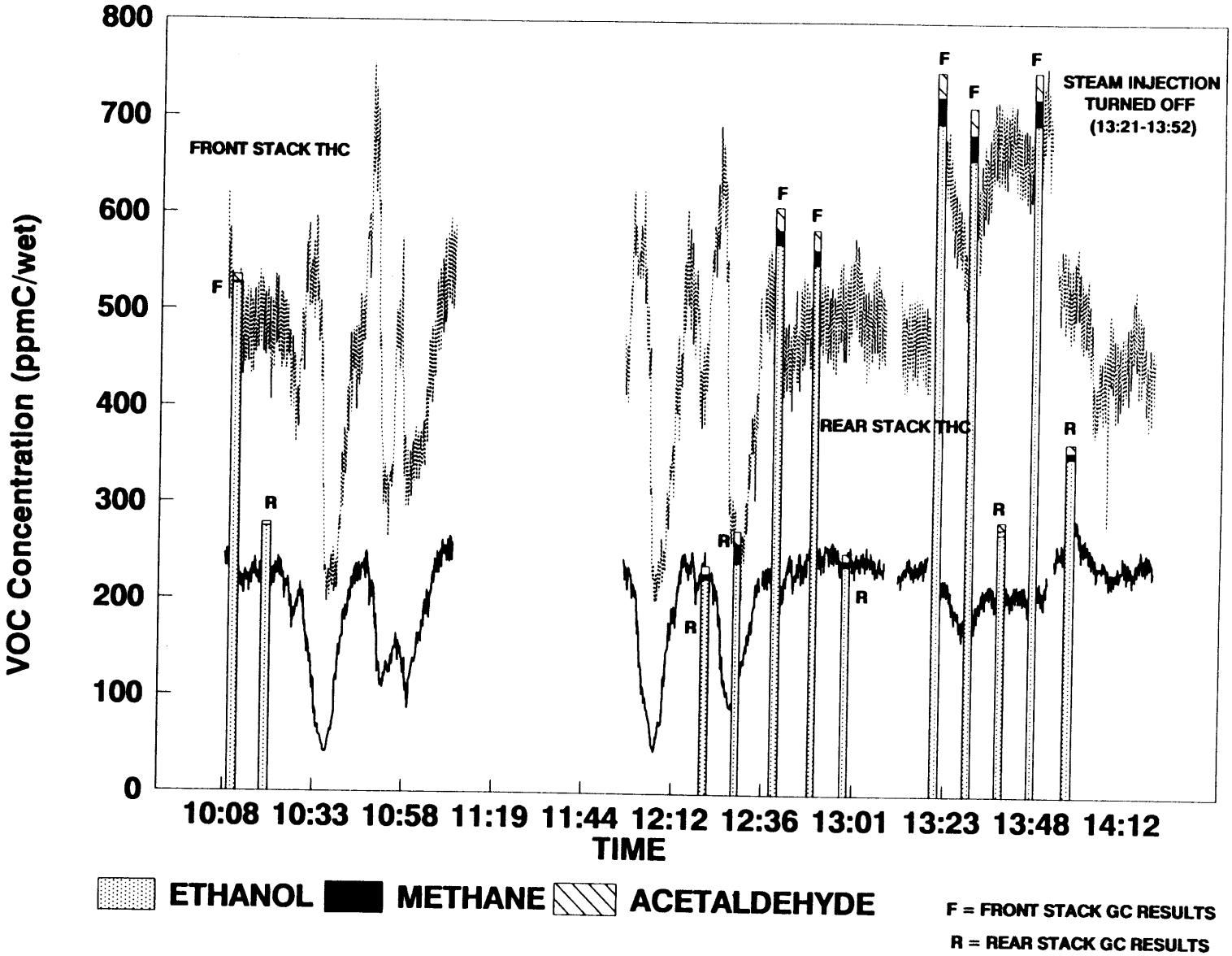

Figure 3-29. Run 29 Method 25A and Method 18 Results (adjusted to ppmC) .

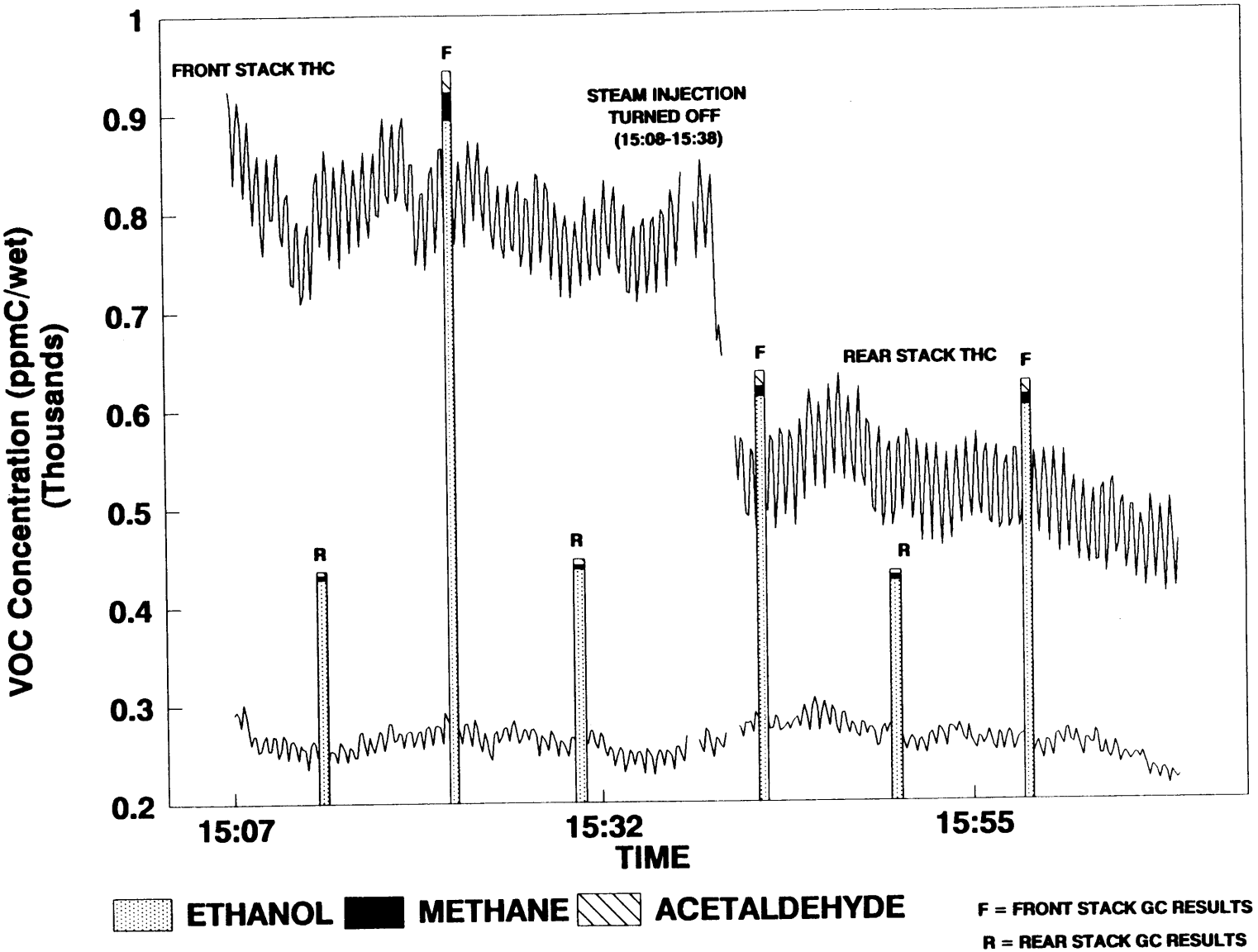

Figure 3-30. Run 30 Method 25A and Method 18 Results (adjusted to ppmC) .

Table 3-24. Summary of Flue Gas Sampling Parameters EPA Bakeries, Site 4 (1992)

Run Number	Location	Stack Gas Temperature (deg F)	Barometric Pressure (in. Hg)	Stack Gas Static Pressure (in H2O)	Volumetric Flow Rate (acfm)	Volumetric Flow Rate (scfm)
Run 22	Front	239	29.75	−0.07	2034.99	1531.47
	Comfort	134	29.75	0	3335.8475	2944.185
	Rear	160	29.75	−0.1	2265.88	1920.34
Run 23	Front	239	29.75	−0.07	2034.99	1531.47
	Comfort	134	29.75	0	3335.8475	2944.185
	Rear	160	29.75	−0.1	2265.88	1920.34
Run 24	Front	239	29.75	−0.07	2034.99	1531.47
	Comfort	134	29.75	0	3335.8475	2944.185
	Rear	160	29.75	−0.1	2265.88	1920.34
Run 25	Front	239	29.75	−0.07	2034.99	1531.47
	Comfort	134	29.75	0	3335.8475	2944.185
	Rear	160	29.75	−0.1	2265.88	1920.34
Run 26	Front	239	29.75	−0.07	2034.99	1531.47
	Comfort	134	29.75	0	3335.8475	2944.185
	Rear	160	29.75	−0.1	2265.88	1920.34
Run 27	Front	239	29.75	−0.07	2034.99	1531.47
	Comfort	134	29.75	0	3335.8475	2944.185
	Rear	160	29.75	−0.1	2265.88	1920.34
Run 28	Front	239	29.75	−0.07	2034.99	1531.47
	Comfort	134	29.75	0	3335.8475	2944.185
	Rear	160	29.75	−0.1	2265.88	1920.34
Run 29	Front [a]	239	29.75	0	141.245	106.455
	Rear [a]	161	29.75	0	2034.16	1723.32
	Front	239	29.75	0	141.245	106.455
	Rear	161	29.75	0	2034.16	1723.32
Run 30	Front [a]	239	29.75	0	141.245	106.455
	Rear [a]	161	29.75	0	2034.16	1723.32
	Front	239	29.75	0	141.245	106.455
	Rear	161	29.75	0	2034.16	1723.32

[a] Testing was performed while steam was injected into the front of the oven.

3.6 Carbon Equivalent Correction Factor Determination

Table 3-25 presents the ethanol carbon equivalent correction factor (CECF) determination. As discussed before, the CECF is the relative response of the THC analyzer in units of ppmC to known concentrations of ethanol. The CECF was determined for both ethanol and acetaldehyde by observing the response of the THC analyzer in units of ppmC to known gas concentrations of the two target compounds. The observed response was divided by the known concentration to determine the CECF value. This was done both in the field and in the laboratory. Ethanol challenges were made in the field at only one concentration (typically 200 ppmv); therefore, it was decided to develop the ethanol CECF over a much wider range of concentrations that were encountered in the field. The CECF value used for this test program was determined in the laboratory using a wide range of ethanol concentration. The average CECF for ethanol was determined to be 1.42. The on-site ethanol QC challenges are presented in Section 6.0.

Table 3-26 presents the acetaldehyde CECF determination. This procedure was performed in the field with a single concentration of acetaldehyde. Only relatively low sample concentrations were observed during the test program (< 50 ppmv); therefore, extensive CECF development did not need to be completed. The acetaldehyde CECF used for this test program was 1.23.

Table 3-25. In-House Ethanol Carbon Equivalent Correction Factor Determination, EPA Bakeries (1992)

Ethanol QC Gas Conc. (ppmC)	Instrument Response (ppmC)	Carbon Equivalent Correction Factor
498	628	1.26
1000	1294	1.29
1470	2055	1.40
2000	2773	1.39
1470	2022	1.38
1470	2097	1.43
498	732	1.47
1000	1499	1.50
1470	2287	1.56
2000	2997	1.50
	AVG	1.42

Table 3-26. Acetaldehyde Carbon Equivalent Correction Factor Determination, EPA Bakeries (1992)

Site	Test Day	Ethanol QC Gas Conc. (ppmC)	System 1		System 2	
			THC Instrument Response (ppmC)	Carbon Equivalent Correction Factor	THC Instrument Response (ppmC)	Carbon Equivalent Correction Factor
1	2	82.5	101.5	1.23	103.5	1.25
3	2	82.5	98.9	1.20	101	1.22
4	3	82.5	103.5	1.25	107	1.30
4	4	82.5	DOWN		100.5	1.22
			AVG	1.23	AVG	1.26

4.0 OVEN CONFIGURATIONS AND SAMPLING LOCATIONS

This section presents a general discussion of the oven stack locations, sampling port locations, and flow traverse point locations. The U.S. EPA Method 1 guidelines were used to determine the majority of test locations measuring gas flow rates. Method 25A and 18 samples were taken from the same port that the flow measurements were made. The sample point was located near the centroid of the duct (centrally located 10% area of the stack cross-section). All locations were at least 2 diameters upstream from the gas discharge to the atmosphere as required in Method 25A.

4.1 General Process Description

The following sections present a general description of the baking process and commercial baking ovens. It is not within the scope of this document to present detailed process information or production rates; therefore, these descriptions are only meant to familiarize the reader of the general principles and equipment used in the commercial baking industry.

4.1.1 Baking Process Description[1]

Bread baking at large commercial bread bakeries is a highly-mechanized process consisting of high-speed production lines with ovens capable of baking 20,000 pounds or more of bread per hour. The process starts with the mixing of flour, water, sugar, and yeast to form dough, thereby initiating a long series of complex biochemical changes which ends in the oven where the bread is baked.

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[1] Compilation of Air Pollutant Emission Factors (AP-42), Chapter 13.01, Bread Baking (Final Draft 1991)

There are four basic types of dough mixing processes: sponge dough, straight dough, brew, and continuous mix ("no-time"). These processes vary in the manner in which the various dough ingredients are mixed which determines the fermentation time available. Fermentation time can vary from 20 minutes or less for the continuous mix or "no-time" process, to 5 hours or more in the sponge dough process. The continuous mix or "no-time" process consists of mixing all of the dough ingredients at the same time; therefore, the fermentation time is minimized by using processing agents and higher temperatures. Sponge dough is formed when two-thirds of the flour, part of the water and the yeast are initially mixed and allowed to ferment before the remaining ingredients are added.

The baking process actually occurs in the oven which causes expansion of the loaf to final volume, crust formation, yeast and enzymatic activity inactivation, coagulation of dough proteins, partial gelatinization of starch, and reduction of loaf moisture. All of these processes are necessary to produce high quality, saleable bread products. To accomplish all of these product and process effects in the proper sequence, commercial bread ovens have between three and eight temperature gradient zones which are maintained in critical balance. Oven rise, which determines the final loaf volume and internal texture, occurs during the first 5-6 minutes of baking. Thermal degradation of the yeast occurs when the internal bread temperature reaches 140-145°F which stops the fermentation process. Protein is denatured between 140-180°F. At the end of the process, browning and crust color develop while ethanol and moisture are evaporated to cool the loaf and prevent the internal temperature from reaching the boiling point of water.[2]

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[2]J. W. Stitley, Baking Technology, Oven Emissions and Control Devices, American Institute of Baking, Manhattan, KS (1986).

There are three fundamental oven types: tunnel, tray, and spiral. Tunnel ovens, as shown in Figure 4-1 are long horizontal ovens where dough enters at one end and is conveyed to the opposite end where it exits as bread. Tray ovens as shown in Figure 4-2 are also horizonal; however, the dough enters the oven and exits on the same side after being conveyed the length of the oven. The tray is lowered to a second level and then conveyed to the exit near where it entered. In spiral ovens, dough enters at the top corner of the oven and is conveyed in a downward spiral to the bottom corner of the oven where it exits through an opening diagonally lower from where it entered the oven. No spiral ovens were tested during this test program. Tunnel and tray ovens typically contain three to five exhaust stacks with one stack typically used for purging the oven of natural gas during ignition and the remaining stacks used during normal baking operations. In contrast, spiral ovens usually contain just one stack which is used during both purging and normal operations.[3]

4.1.2 Oven Heating Systems[4]

Ovens may be divided into two general categories according to the manner in which they are heated, namely, direct-fired ovens and indirect-fired ovens. A third category makes use of semi-direct heating. In direct-fired ovens, the burners are located directly within the baking chamber and are usually ribbon type and burn natural gas. Modern ovens normally feature banks of ribbon burners located both above and below the baking surface, across the path of travel of the baking trays or oven band. Most such ovens are equipped with an external forced-air agitation system to augment the naturally formed convection currents within the baking chamber.

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[3]BAAQMD Staff Report Supporting Adoption of Rule 8-42 (July 1988).

[4] The Science of Baking, Lesson 26 Bakery Ovens, American Institute of Baking (no date)

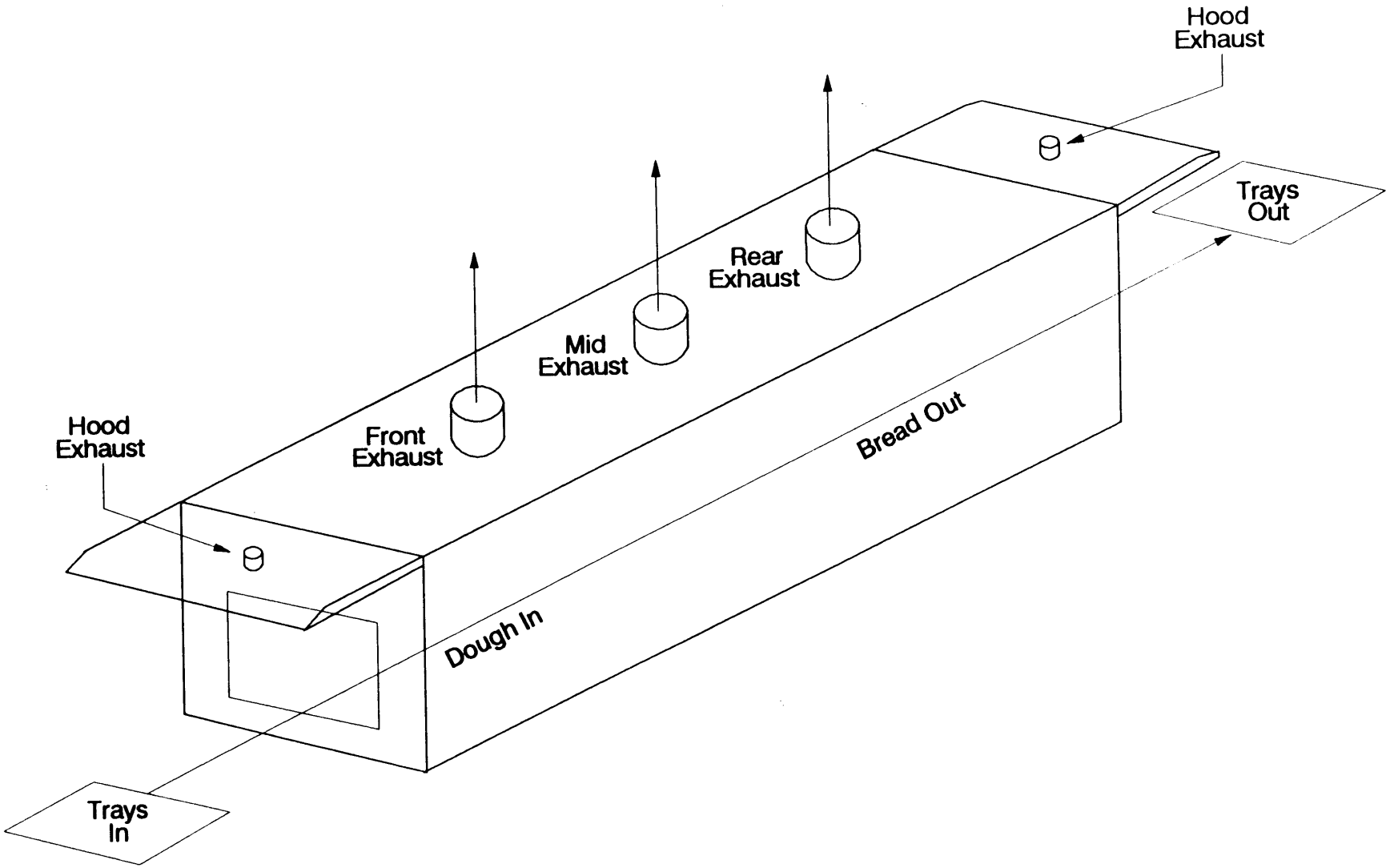


Figure 4-1. Generalized Schematic of a "Tunnel" Type Baking Oven EPA Bakeries (1992)

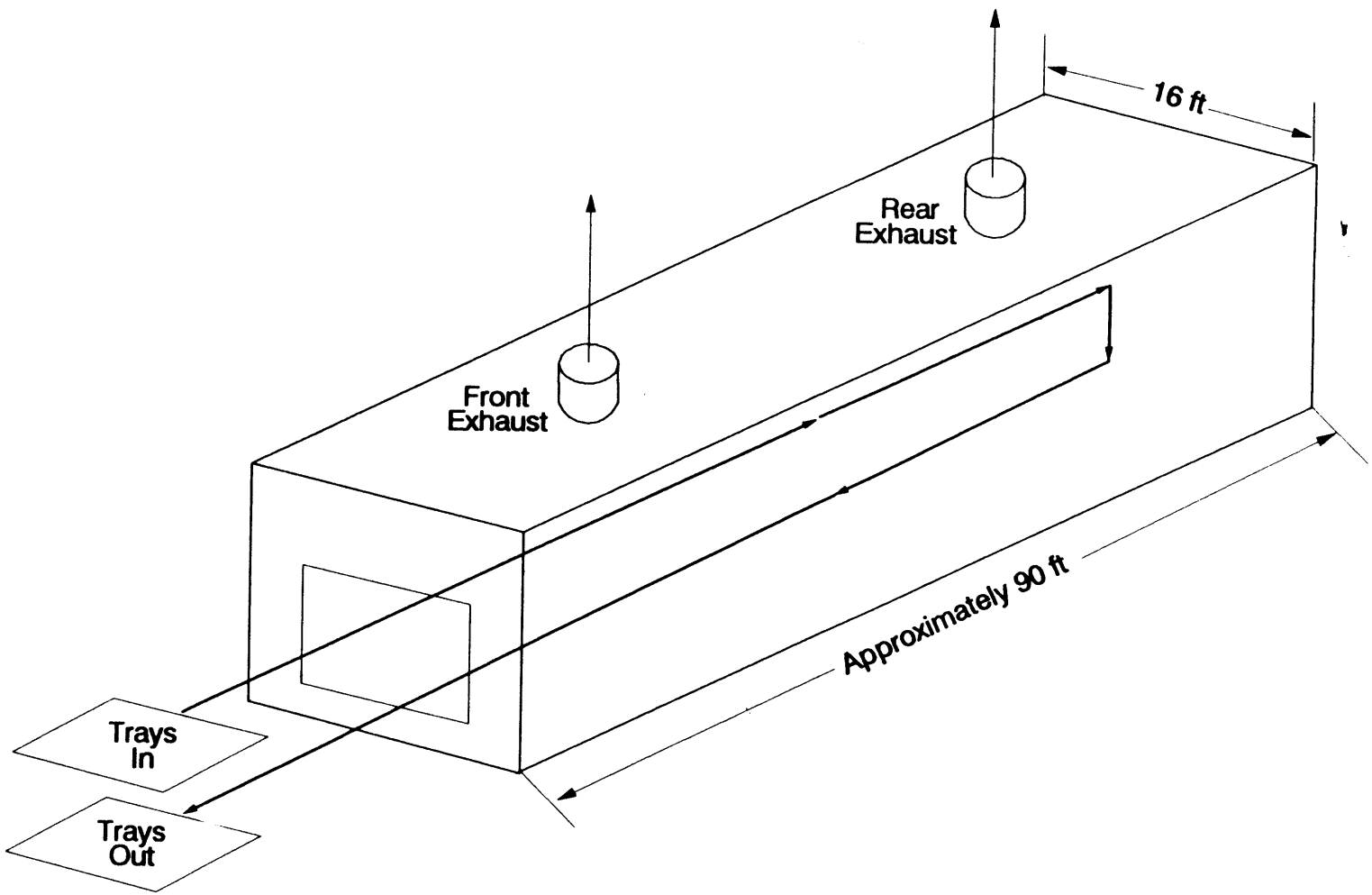


Figure 4-2. Generalized Schematic of a "Tray" Type Baking Oven EPA Bakeries (1992)

In indirect-fired ovens, the combustion chamber is isolated from the baking chamber. The heat is transferred from the hot combustion gases to the baking chamber by means of flues or radiator tubes. In these ovens, the products of combustion do not enter the baking chamber and thus do not come into direct contact with the baking products. The heat is generated by single high-capacity burners (one burner for each oven zone) and radiant heat is supplied by the flues and radiators within the baking chambers. Forced air agitation systems and improved oven efficiency are a general feature of indirect-fired ovens.

Semi-direct fired ovens (which are also referred to as semi-indirect fired ovens) closely resemble indirect-fired ovens in their use of separate combustion chambers and of radiator tubes for the heat transfer. In their case, however, the radiator tubes have either thin slots or small holes that allow the hot combustion gases to enter the baking chamber. These gases create convection currents whose intensity can be controlled by means of baffles. Thus, semi-direct fired ovens combine the advantages of both convection and radiant heat transfers.

4.2 Test Program Overview

This test program involved measuring the emissions from both direct- and indirect-fired ovens. Some of the indirect fired units had their heat exchanger tubes drilled out to promote better heating efficiency. However, maintenance records were incomplete and plant personnel were uncertain whether this had been completed or not. In some instances, maintenance personnel stated that their indirect-fired ovens had not been drilled out and yet high concentrations of unburned methane (>1000 ppmv) were detected in the stack gases. So a strict direct/ indirect firing classification was not always possible.

Another important facet of the test program was that during steady-state operation, the gas flow in some of the stacks would almost be completely shut off with a

flow damper to prevent oven heat loss. The Method 25A and 18 tests would detect fairly high concentrations of THC (>1000 ppmC) while flow rates would be minimal (< 100 cfm), resulting in fairly low emissions rates. The flow damper positions were always verified to ensure they were the same during both flow measurement tests and the Method 25A and 18 tests.

The majority of ovens tested had two stacks venting exhaust gases. If both stacks vented oven (baking) gases (i.e., direct-fired), they were referred to as the front stack and the rear stack depending on their respective location. Front stacks were located near the end of the oven where the bread dough entered, and the rear stacks were on the opposite end.

Indirect-fired ovens also typically had two stacks with one stack exhausting the oven gases and the other exhausting the burner gases. Gases from the burner stack were expected to be comprised mainly of unburned hydrocarbons (i.e. methane). However as previously mentioned, oven maintenance records were sometimes incomplete and what was expected to be purely a burner exhaust gas stream, was sometimes comprised of significant portions of gases from the baking processes (i.e. ethanol and acetaldehyde).

Two sites had a third stack (typically referred to as comfort hoods) venting the gases, which was either adjacent to the oven entrance or to the exit. (See Figure 3-1). Their purpose was to remove fugitive oven heat from worker areas. Gases were pulled from these locations through a ventilation hood configuration, typically spanning the width of the oven (10-15 feet) and 1 - 3 feet in length. Exhausts from the Site 2 comfort hoods were pulled through roof ventilator fans which had very little ductwork downstream of an axial fan. This made determining flow rates inaccurate since measurement locations could not be located in accordance with the U.S. EPA Method guidelines. However, Site 4 had comfort hoods which exhausted through typical stacks and flows could be measured according to the U.S. EPA guidelines.

The majority of stacks were small roof vent ducts with an inside diameter (ID) ranging from 12 to 16 inches. As shown in Figures 4-1 and 4-2, the stacks were typically arranged in a straight line (i.e., in line with the orientation of the oven). Most had rain caps installed over the opening which was typically 6-15 feet above the roof. All stacks were accessed from the roofs of the facilities and sample ports were located from 2-6 feet above the roof line. A 1.75 inch hole in the duct walls allowed for full insertion of the Method 25A and 18 sample probe. Two ports were located 90° apart at the same elevation. The sample port that was not being used was always capped off to prevent any ambient air from diluting the sample stream.

Approximately 100 to 150 feet of heated Teflon® tubing was used to transport the gas sample from the stack to the mobile continuous emissions monitoring (CEM) vehicle that was typically parked adjacent to the bakery wall. In cases where there were three stacks originating from the oven, one sampling probe/heat trace system would be alternated from the second and third stack.

A general description of sample locations is presented according to the respective test site in the following section.

4.3 Site 1 Sample Locations

A large Bread oven and a smaller bun oven were tested at the first facility. Both ovens were tested with the CEM trailer parked in the same location on two separate test days.

The Bread oven was a direct-oven which had three main vent stacks arranged longitudinally. The middle stack is used only during the oven purging (start-up) and was capped off with a small metal drum during the emissions tests. The absence of flow at this stack was confirmed using a sensitive hot-wire anemometer (0-600 fpm scale). After the test was completed, it was later discovered that there was a comfort

hood located at the oven exit. Gases from the hood were directed up through a vent stack on the roof. However, this stack was not tested during the test program.

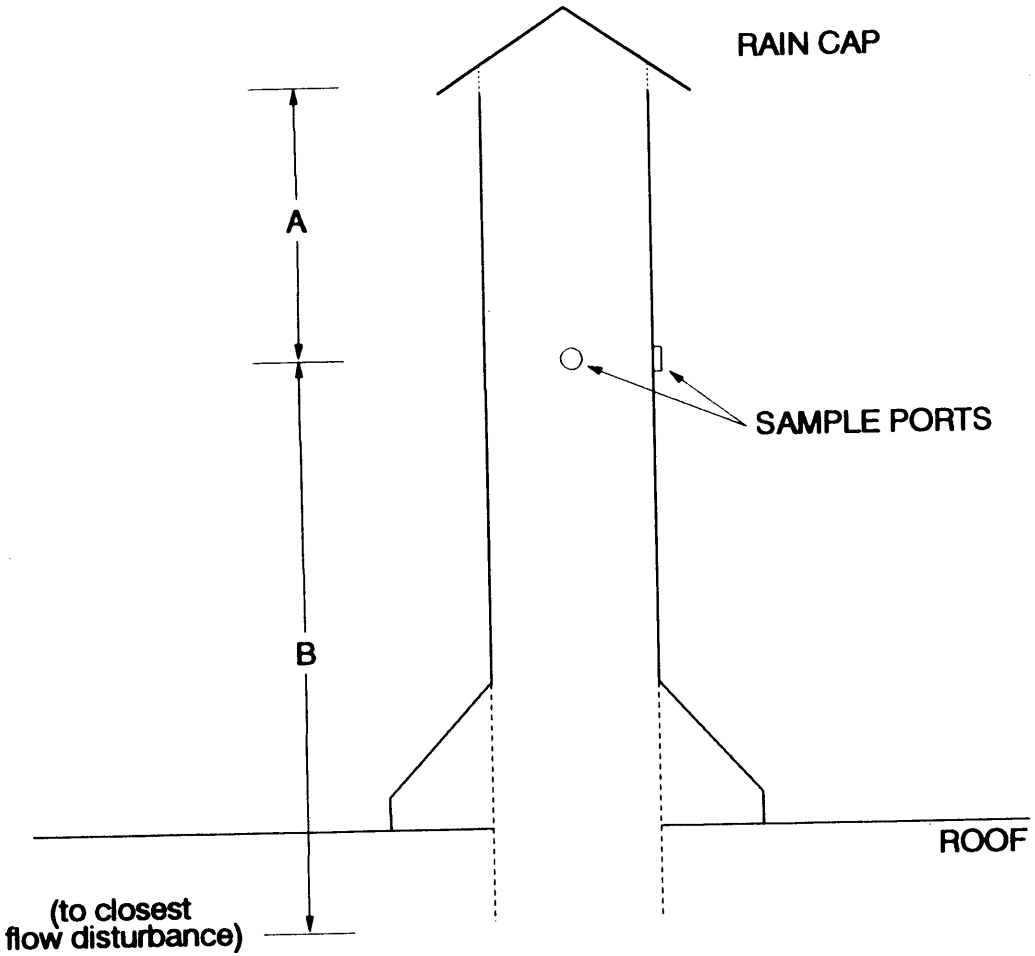
The front stack on the Bread oven was sampled using a 150-foot length of heat-traced sample tubing. The location of the rear stack necessitated a 200-foot section, whereas the front stack was assessable with a 150-foot section. Both the front and rear stacks were approximately 7.5 feet high (from roof level) with 14-inch ID. As shown in Figure 4-3, both stacks had a rain cap configured on the gas exit. Ports on both stacks were located approximately 10-feet (8.5 diameters) downstream and 3-feet (2.5 diameters) upstream of the nearest flow disturbances. Eight traverse points was used to measure flows.

The Site 1 roll line used another direct-fired oven with two vent stacks. As shown in Figure 4-4, both stacks had a 12-inch ID with rain caps and were located approximately 8-feet (8 diameters) downstream and 3-feet (3 diameters) upstream of the nearest flow disturbances. Flows were measured at 8 traverse points.

4.4 Site 2 Sample Locations

A small bun oven, a small bread oven and a large bread oven were tested at the Site 2. These ovens were also identified as Lines 1 through 3, respectively. Line 1 and 2 ovens were tested with the CEM trailer parked in the same parking location. The trailer had to be moved to test the third oven (Line 3).

The oven on Line 1 had two stacks and a comfort hood; however, neither stack had a rain cap. The sampling locations are shown in Figure 4-5. The front stack and comfort hood were sampled alternately using a 150-foot length of heat-traced sample line. The location of the rear stack necessitated a 200 foot length. Both the front and rear stacks had a 12-inch ID. Ports were located approximately 9-feet (9 diameters)



SITE 1 BREAD OVEN
SAMPLING AND FLOW
MEASUREMENT LOCATIONS

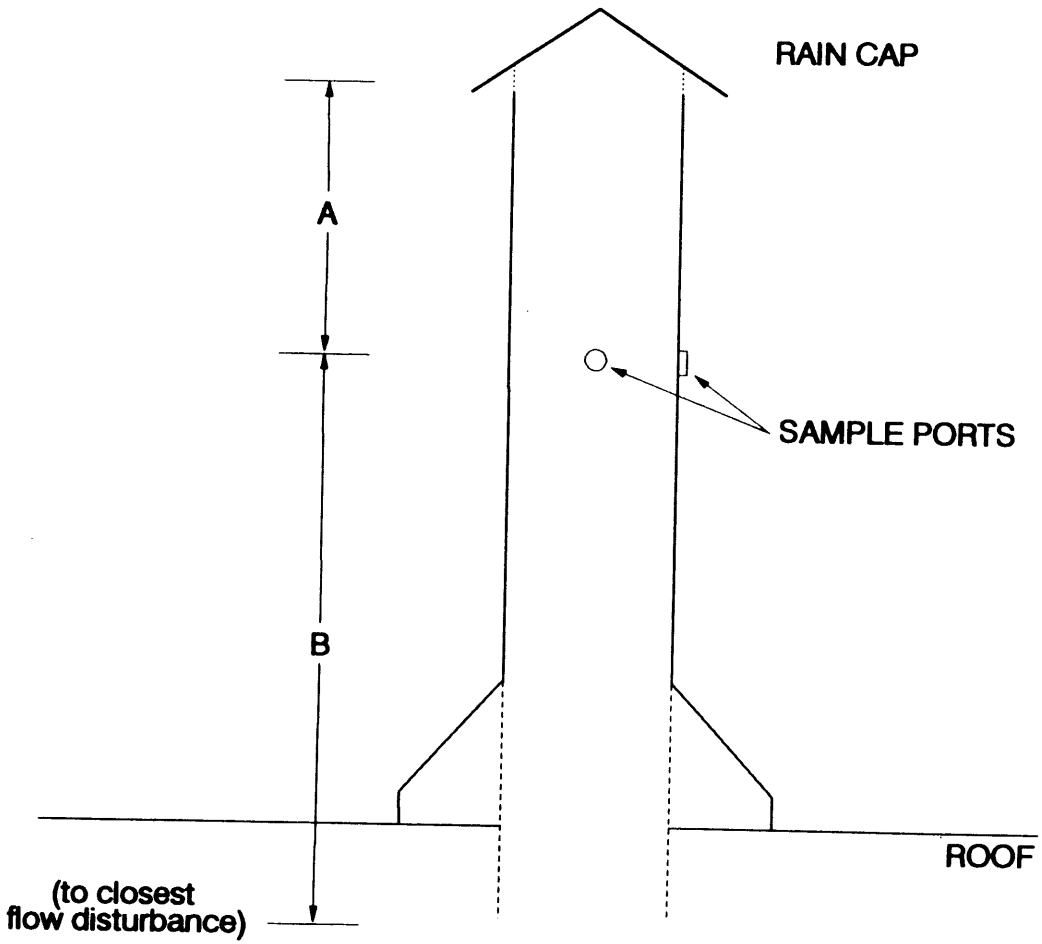
Front Stack

14 in. ID	No. of Flow Traverse Pts.
A = ~3 ft	
B = > 10 ft	8

Rear Stack

14 in. ID	No. of Flow Traverse Pts.
A = ~3 ft	
B = > 10 ft	8

FIGURE 4-3. SITE 1 BREAD OVEN STACK CONFIGURATION
EPA BAKERIES (1992)



SITE 1 BUN OVEN
SAMPLING AND FLOW
MEASUREMENT LOCATIONS

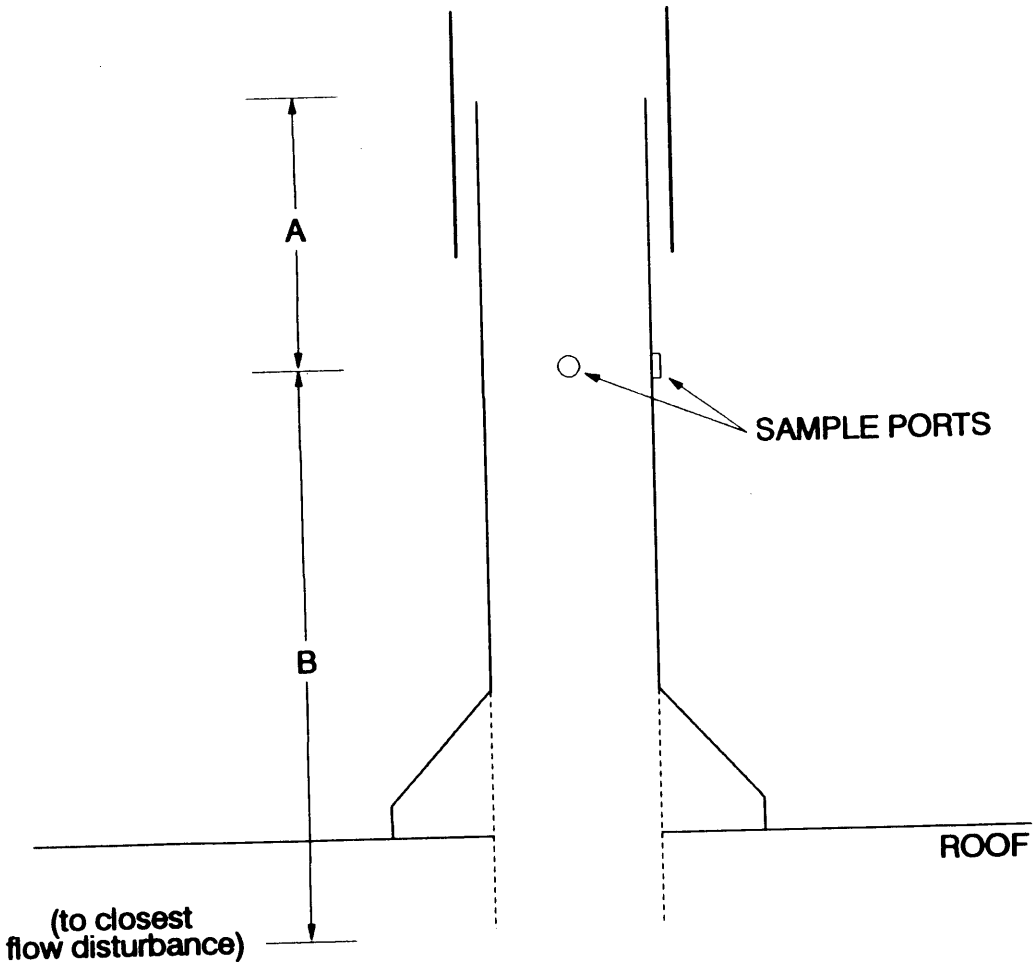
Front Stack

12 in. ID	No. of Flow Traverse Pts.
A = ~3 ft	
B = > 8 ft	8

Rear Stack

12 in. ID	No. of Flow Traverse Pts.
A = ~3 ft	
B = > 8 ft	8

FIGURE 4-4. SITE 1 BUN OVEN STACK CONFIGURATION
EPA BAKERIES (1992)



SITE 2 LINE 1 BUN OVEN
SAMPLING AND FLOW
MEASUREMENT LOCATIONS

Front Stack

12 in. ID	No. of Flow Traverse Pts.
A = ~2 ft	8
B = 9 ft	

Rear Stack

12 in. ID	No. of Flow Traverse Pts.
A = ~2 ft	8
B = 9 ft	

Comfort Hood Stack
(see Figure 4-6)

FIGURE 4-5. SITE 2 LINE 1 BUN OVEN STACK CONFIGURATION
EPA BAKERIES (1992)

downstream and 2-feet (2 diameters) upstream of the nearest flow disturbances. Flow was measured at 8 traverse points.

All of the comfort hoods at Site 2 were exhausted by axial fan roof ventilator (Dayton Model 3C276-A). There was no ductwork following the fan; therefore, U.S. EPA Method 1 specifications were not met. Flow measurements had to be taken directly after the fan as it was exhausted to atmosphere. The general configuration is shown in Figure 4-6. Six traverse points were located as shown.

The comfort hod fan on Line 1 was not operating during the test and had evidently not operated for some time. Gas flow was induced by strictly natural drafting of the hot gases at velocities of 50-300 fpm and at temperatures of 150°F.

The Line 2 was an indirect-fired unit and the oven gases were vented from a stack located in the front of the oven and the burner stack was located in the rear. As with the Bun oven, there was a comfort hood that was vented by a axial fan roof ventilator. There was no gas duct work following the fan; therefore, the flow measurement could not be made at a location in accordance with the U.S. EPA Method 1 procedures. Flows were estimated by both velocity pressure measurements and hot-wire anemometer measurements.

The sampling locations on Line 2 are shown in Figure 4-7. The oven (front) stack was 11.5-inch ID with a rain cap. Ports were located 5.5-feet (5.7 diameters) downstream and 1.0-feet (1.0 diameters) upstream of the nearest flow disturbances. Flow was measured at 16 traverse points.

The burner stack on Line 2 had a 16-inch ID without a rain cap. Ports were located approximately 4-feet (3.0 diameters) downstream and 2-feet (1.5 diameters) upstream of the nearest flow disturbances. Flow was measured at 16 traverse points.

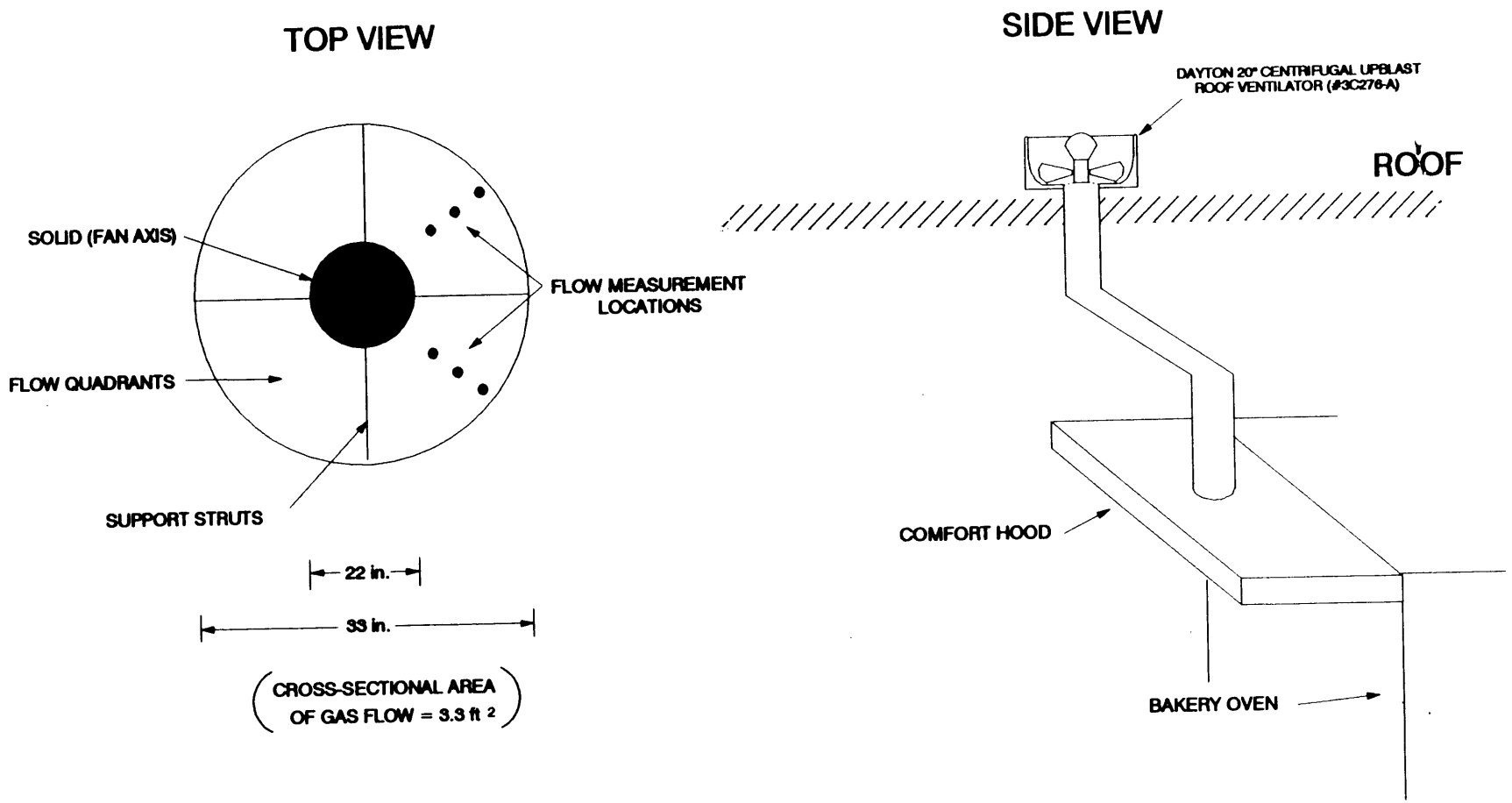
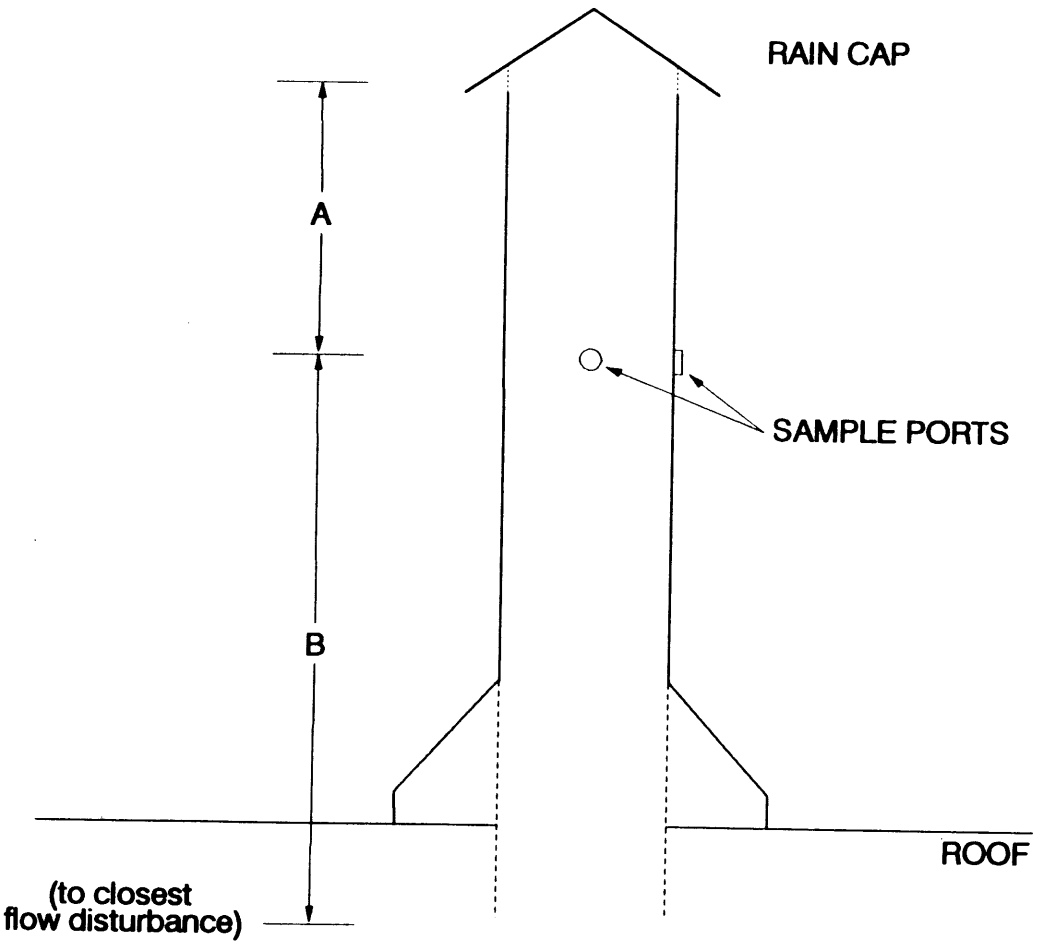


FIGURE 4-6. GENERAL SCHEMATIC OF THE SITE 2 COMFORT HOOD EXHAUST FANS EPA BAKERIES (1992)



SITE 2 LINE 2 BREAD OVEN
SAMPLING AND FLOW
MEASUREMENT LOCATIONS

Front Stack

11.5 in. ID	No. of Flow
A = ~1 ft	Traverse Pts.
B = ~5.5 ft	16

Rear Stack (Burner)*

16 in. ID	No. of Flow
A = 2 ft	Traverse Pts.
B = 4 ft	16

* Rear stack did not have rain cap.

Comfort Hood Stack
(see Figure 4-6)

FIGURE 4-7. SITE 2 LINE 2 BREAD OVEN STACK CONFIGURATION
EPA BAKERIES (1992)

The comfort hood on Line 2 was identical to that described except that the fan was operating. Flows were measured as described above.

The Bread oven on Line 3 was a direct-fired unit with stacks located approximately 90 feet apart. There were 2 oven stacks and a comfort hood. The front stack and comfort hood were alternately sampled using a 100-foot section of heat-traced tubing. The rear stack was sampled using a 150-foot section.

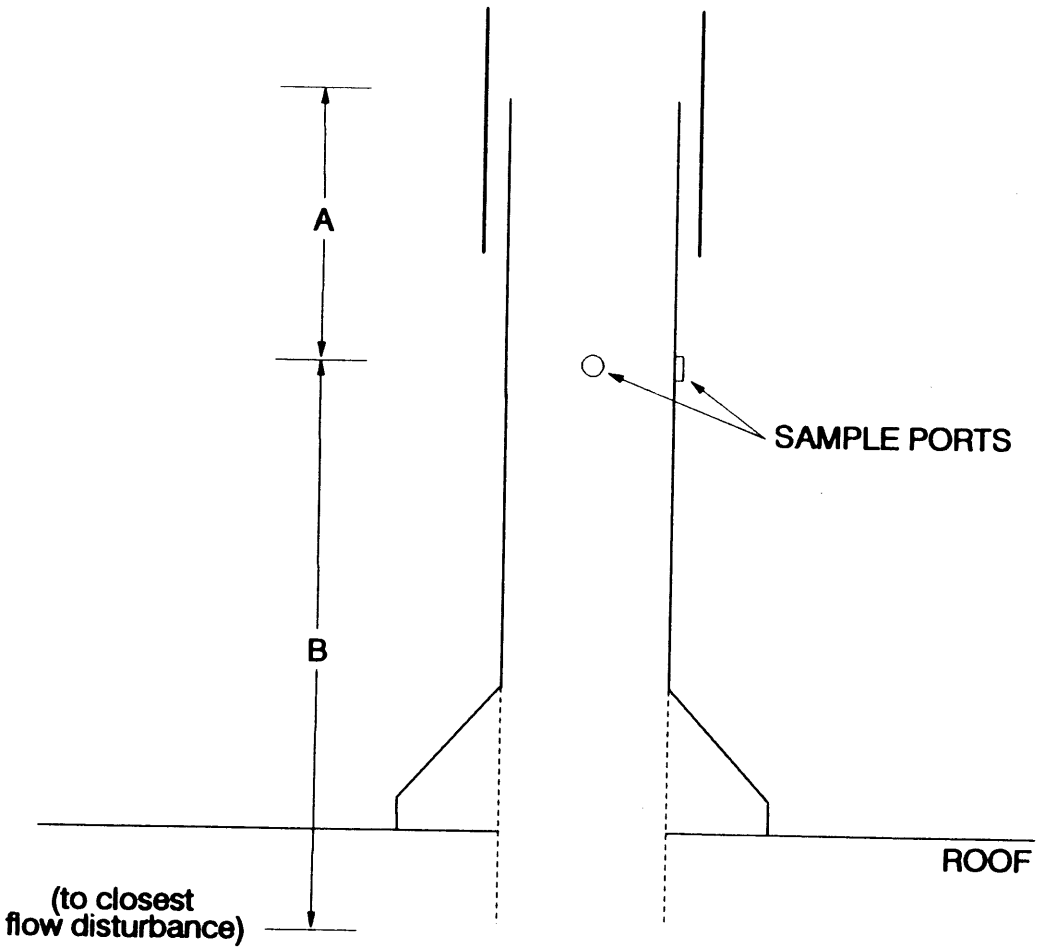
The sampling locations on Line 3 are shown in Figure 4-8. The front stack had a 13.75-inch ID. Rain caps were not present on any of the Line 3 stacks. Ports on the front stack were located 11-feet (9.6 diameters) downstream and 2.5-feet (2.2 diameters) upstream of the nearest flow disturbances. Flow was measured at 8 traverse points.

The rear stack on Line 3 had a 15.5-inch ID. Ports were located approximately 11-feet (8.9 diameters) downstream and 2.5-feet (1.9 diameters) upstream of the nearest flow disturbances. Flow was measured at 8 traverse points.

The comfort hood on Line 3 was identical to that described and the fan was operating. Flows were measured as described above.

4.5 Site 3 Sample Locations

A small bun and a small oven designated for baking bread was tested at Site 3. Both ovens were tested with the CEM trailer located in the same parking location. The bun oven was identified as indirect-fired with three stacks. Two of the stacks were designated for the two burners and the third stack was an exhauster which vented oven gases. During normal operation the main flow damper on this oven was closed. The stack gas flow was 50-100 acfm during testing. The tests were conducted



SITE 2 LINE 3 BREAD OVEN
SAMPLING AND FLOW
MEASUREMENT LOCATIONS

Front Stack

13.75 in. ID	No. of Flow Traverse Pts.
A = 2.5 ft	
B = 11 ft	8

Rear Stack

15.5 in. ID	No. of Flow Traverse Pts.
A = 2.5 ft	
B = 11 ft	8

Comfort Hood Stack
(see Figure 4-6)

FIGURE 4-8. SITE 2 LINE 3 BREAD OVEN STACK CONFIGURATION
EPA BAKERIES (1992)

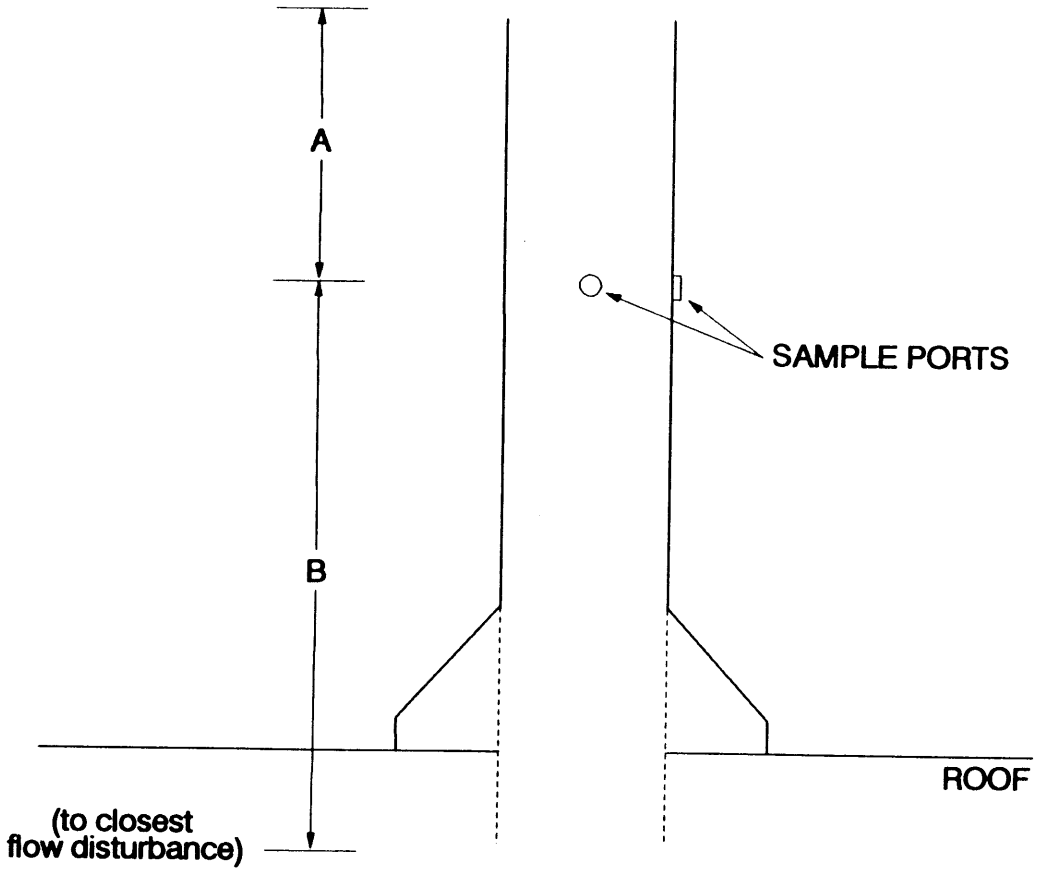
keeping one sample/THC analytical system on the exhauster stack and alternating the other sample/THC system from "Burner 1" and "Burner 2".

The sampling locations for the Bun oven are shown in Figure 4-9. The burner stacks were oriented about 10-15 feet apart on the oven longitudinal axis with the Burner 1 stack closer to the rear of the oven. The length of heat trace used for all Site 3 stacks was 150 feet. Both burner stacks were 12-inches ID with no rain caps. Ports were located 10-feet (10 diameters) downstream and 10-feet (10 diameters upstream from the closest flow disturbances. Flow was measured at 8 traverse points.

The bun exhauster stack was 12-inches ID. Ports were located 10-feet (10 diameters) downstream and 10-feet (10 diameters) upstream of the nearest flow disturbances. The measured flow rates were approximately 50-100 fpm which necessitated the use of a hot-wire anemometer for flow measurement. Flow was measured at 8 traverse points.

The Bread oven at Site 3 sampling locations are shown in Figure 4-10. This oven was also indirect-fired. There was a single burner stack and a single oven vent stack located approximately 30 feet apart along the longitudinal axis. The burner stack was 15.5 inches ID with a rain cap located on top. Ports were located 8.5-feet (6.6 diameters) downstream and 16-feet (12.4 diameters upstream from the closest flow disturbances. Twelve traverse points were used for measuring flow rates.

The oven stack was 12-inches ID with a rain cap located on top. Ports were located 8 ft (8 diameters) downstream and 7 ft (7 diameters upstream from the closest flow disturbances. Eight traverse points were used for measuring flow rates.



SITE 3 BUN BREAD OVEN
SAMPLING AND FLOW
MEASUREMENT LOCATIONS

Front Stack

12 in. ID	No. of Flow
A = 10 ft	Traverse Pts.
B = 10 ft	8

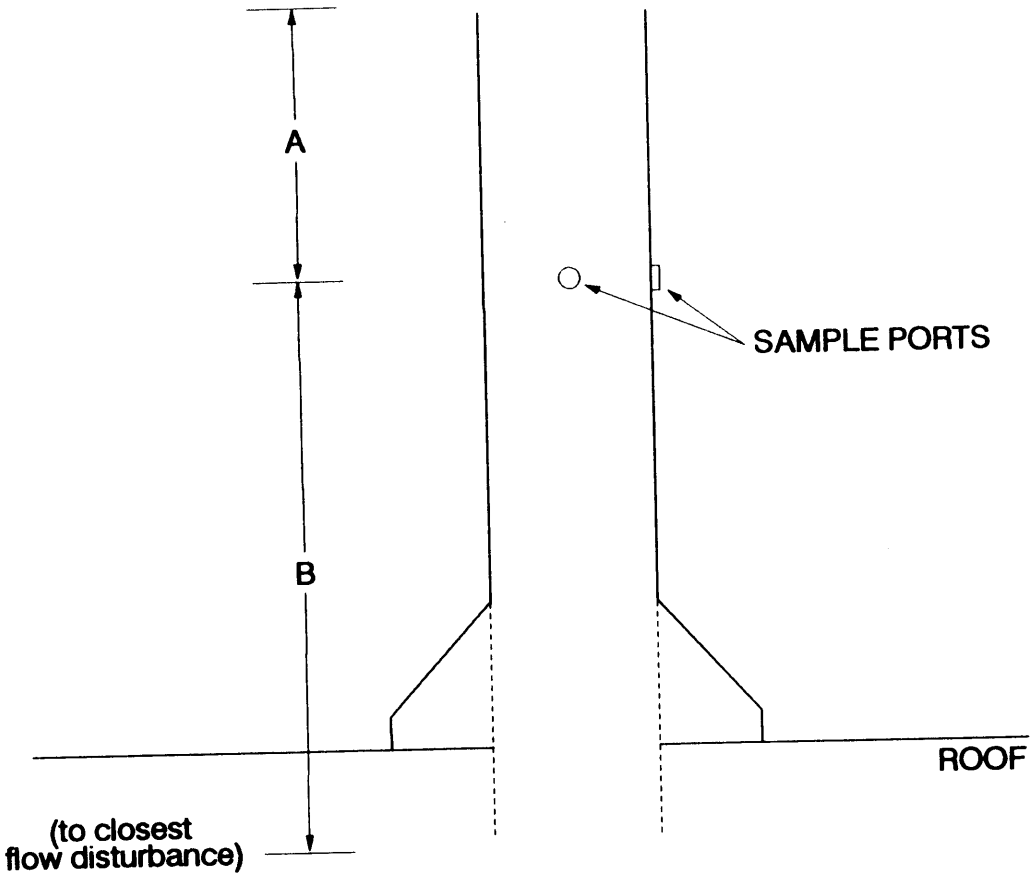
Burner 1 Stack

12 in. ID	No. of Flow
A = 10 ft	Traverse Pts.
B = 10 ft	8

Burner 2 Stack

12 in. ID	No. of Flow
A = 10 ft	Traverse Pts.
B = 10 ft	8

FIGURE 4-9. SITE 3 BUN OVEN STACK CONFIGURATION
EPA BAKERIES (1992)



SITE 3 BREAD OVEN
SAMPLING AND FLOW
MEASUREMENT LOCATIONS

Front (exhauster) Stack

12 in. ID	No. of Flow Traverse Pts.
A = ~7 ft	
B = ~8 ft	8

Burner Stack

15.5 in. ID	No. of Flow Traverse Pts.
A = ~16 ft	
B = ~ 8.5 ft	12

FIGURE 4-10. SITE 3 BREAD OVEN STACK CONFIGURATION
EPA BAKERIES (1992)

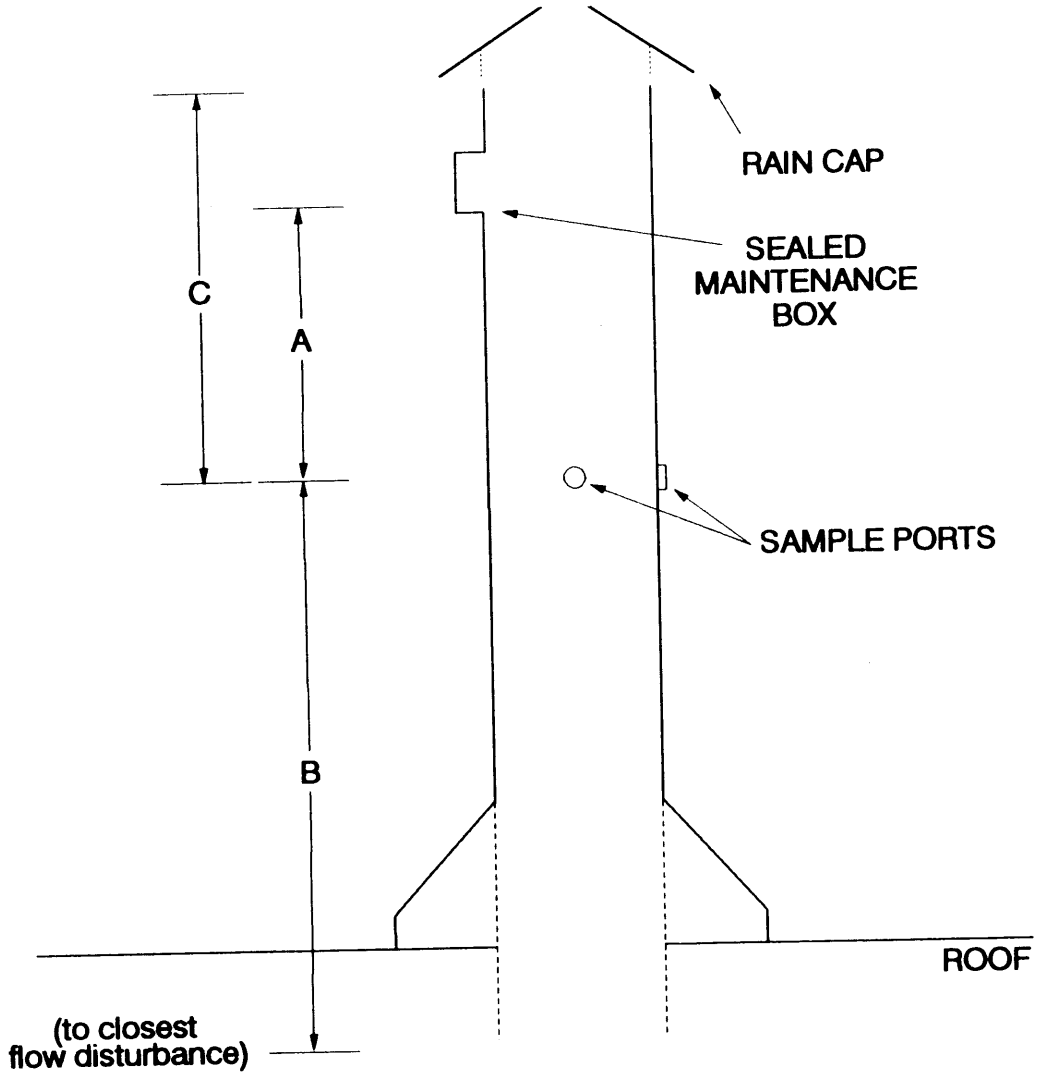
4.6 Site 4 Sample Locations

A large Bread oven and a small Bun oven were tested at Site 4. The Bread oven was tested for 3 test days. The CEM trailer had to be moved for the fourth and final test day in order to reach the Bun oven.

The Bread oven was a direct-fired unit with four stacks located on the unit. However, one of the stacks, located longitudinally in center of the oven, was a propane burner stack strictly used for oven startup conditions and was not tested. The absence of flow and high temperature at this stack was verified on-site. The other three stacks were a front, rear, and a comfort hood stack. The comfort hood stack flow measurement location met the U.S. EPA Method 1 guidelines. A 100-foot length of heat trace tubing was used on the rear stack and a 150-foot length was alternated between the front stack and the comfort hood stack.

The sampling locations used on the Bread oven at Site 4 are shown in Figure 4-11. The Bread oven front stack was 14-inches ID without a rain cap. Ports were located approximately 5-feet (4.3 diameters) downstream and 1-feet (0.86 diameters) upstream from the closest flow disturbances. The ports were 9.0-feet (7.7 diameters) upstream of the final gas exit to atmosphere. Flow was measured at 16 traverse points.

The rear stacks on the Bread oven was 16-inches ID without a rain cap. Ports were located approximately 5.3-feet (4.0 diameters) downstream and 1-feet (0.75 diameters) upstream from the closest flow disturbances. The ports were approximately 10-feet (7.5 diameters) upstream of the final gas exit to atmosphere. Flow was measured at 16 traverse points.



SITE 4 BREAD OVEN
SAMPLING AND FLOW
MEASUREMENT LOCATIONS

Front Stack

14 in. ID	No. of Flow Traverse Pts.
A = ~1 ft	
B = ~ 5 ft	16
C = ~ 9 ft	

Rear Stack

16 in. ID	No. of Flow Traverse Pts.
A = 1.0 ft	
B = 5.3 ft	16
C = ~10 ft	

Comfort Hood Stack

24 in. ID	No. of Flow Traverse Pts.
A = NA ft	
B = ~ 7 ft	16
C = ~7 ft	

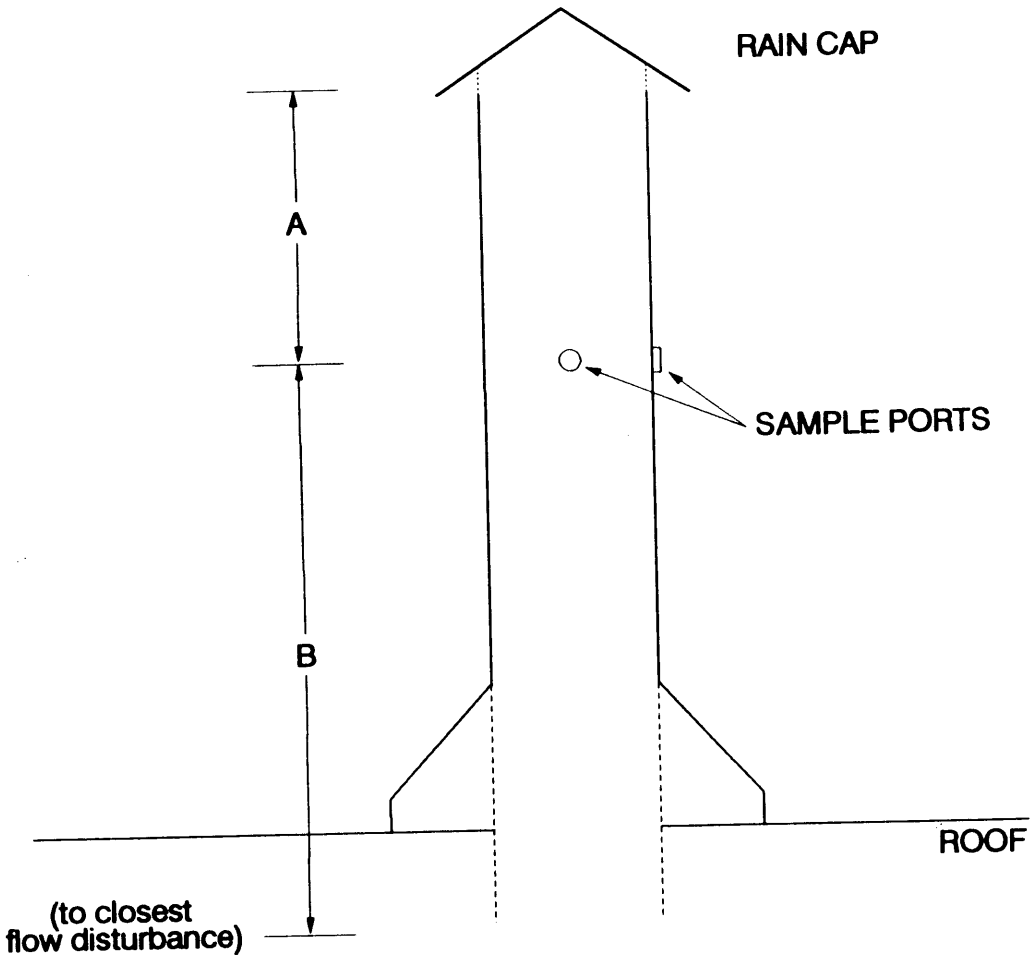
FIGURE 4-11. SITE 4 BREAD OVEN STACKS CONFIGURATIONS EPA BAKERIES (1992)

The Bread oven comfort hood stack had a 24-inch ID without a rain cap. Ports were located 7-feet (3.5 diameters) downstream and 7-feet (3.5 diameters) upstream from the closest flow disturbances. Flow was measured at 16 traverse points.

The Bun oven at Site 4 was a direct-fired unit with two stacks. The front stack had minimal flow similar to the exhauster stack at the Site 3 bun oven and had unusually high gas moisture levels of approximately 30% by volume (%v). This was because the Bun oven was operated with a small amount of steam (approximately 5 psi) injected near the front entrance to give the buns a crisp crust. All other stacks that were tested had gas moisture levels of approximately 5-6%v. Flow rates in the rear stack appeared to be typical of the majority of stacks tested (approximately 1000 acfm). The rear stack was sampled using a 100-foot length of heat trace while the front stack necessitated a 150-foot section.

The sampling locations on the Bun oven at Site 4 are shown in Figure 4-12. The Bun oven front stack had a 14-inch ID with a rain cap located on top. Ports were located 12-feet (10.3 diameters) downstream and 8-feet (6.9 diameters) upstream from the closest flow disturbances. Flow was measured at 16 traverse points.

The Bun oven rear stack had a 16-inch ID with a rain cap. Ports were located 11-feet (8.25 diameters) downstream and 7-feet (5.25 diameters) upstream from the closest flow disturbances. Flow was measured at 16 traverse points.



SITE 4 BUN OVEN
SAMPLING AND FLOW
MEASUREMENT LOCATIONS

Front Stack

14 in. ID	No. of Flow Traverse Pts.
A = ~8 ft	16
B = > 12 ft	

Rear Stack

16 in. ID	No. of Flow Traverse Pts.
A = ~7 ft	16
B = ~11 ft	

FIGURE 4-12. SITE 4 BUN OVEN STACK CONFIGURATION
EPA BAKERIES (1992)

5.0 SAMPLING AND ANALYTICAL METHODS

This section briefly summarizes the procedures used for sampling and analysis. Procedures are presented for Method 25A testing in Section 5.1, Method 18 procedures in Section 5.2, and Methods 1-4 procedures in Section 5.3. The detailed protocols can be found in the U.S. EPA reference methods located in the appendices.

5.1 Method 25A Sampling and Analysis for THC

Total hydrocarbon concentration was determined on a continuous basis using the U.S. EPA Method 25A procedure. Procedures incorporate QA/QC protocols stipulated as "Measurement System Performance Specifications" in the reference methods. The QA parameters will be reported in Section 6.0 while the QC procedures are fully detailed in the test plan written for this test program.

The following discussion presents Sample Extraction Equipment and Procedures in Section 5.1.1, THC Analyzers and Operating Principal in Section 5.1.2, Data Acquisition Procedures in Section 5.1.3, Instrument Calibration in Section 5.1.4, and an Example Daily Operating Procedure in Section 5.1.5.

5.1.1 Sample Extraction Equipment and Procedure

A continuous gas sample was extracted from the stack and transported to the analyzer through a heated Teflon® sample line (heat trace). The gas only came into contact with inert materials such as stainless steel, glass, or teflon. The sample gas temperature was maintained above 100°C (212°F) so that there was no condensation of moisture or hydrocarbons in the tubing. A generalized schematic of a typical extractive system is shown in Figure 5-1.

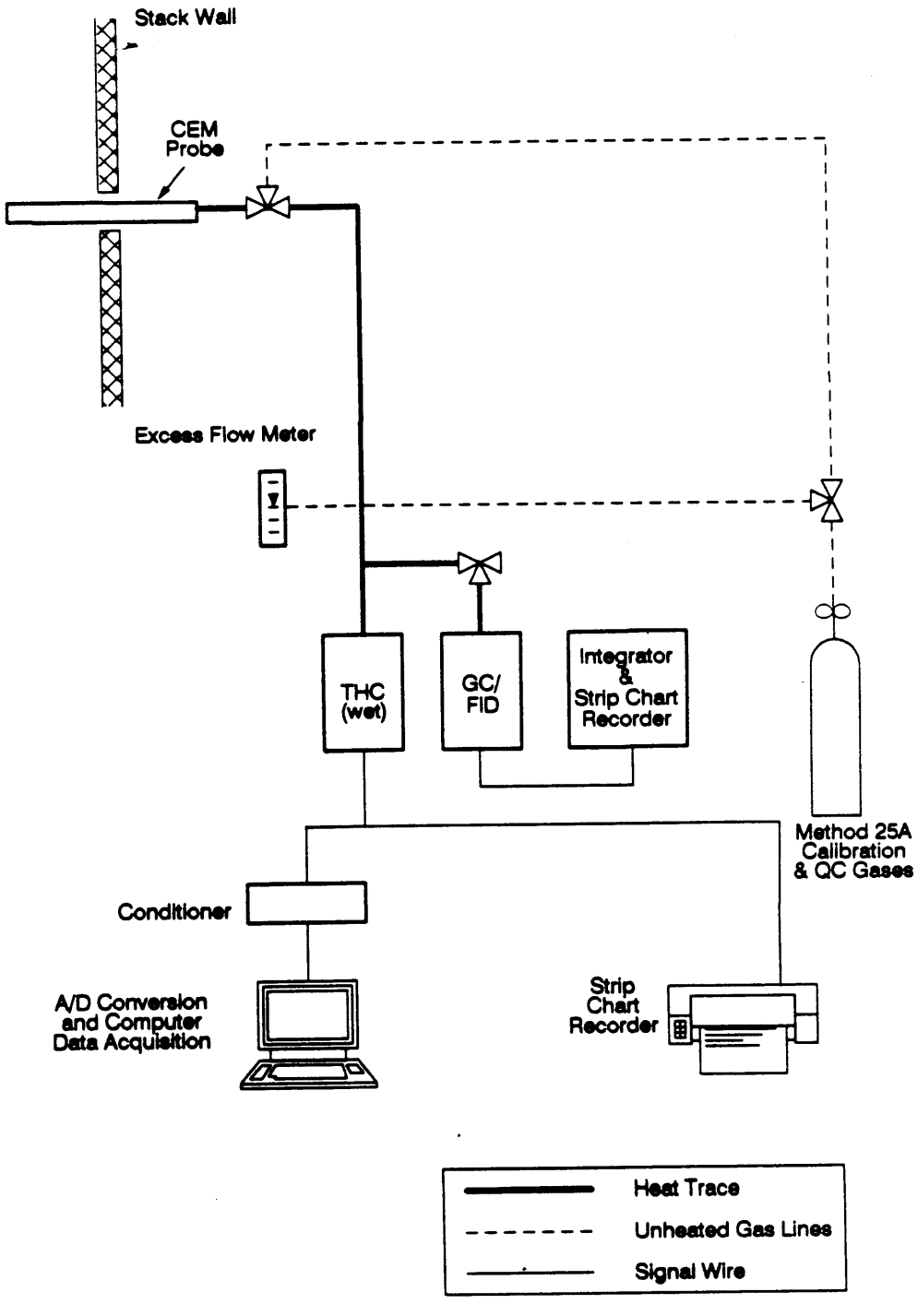


Figure 5-1. General Schematic of Method 18/25A Extractive Stack Gas Sampling System

The probe was used to extract gas from the stack was constructed of a short length of stainless steel or teflon tubing. The gas was extracted using a heated head pump that was placed just upstream of the THC analyzer. An excess flow dump was also upstream from the analyzer, so that the gas in the analyzer would not be under any back pressure created by the sample pump.

In addition to one heated sample tube for sample gas extraction, a separate tube was run from the calibration gas cylinders to the probe. This tube was connected to the system with a 3-way valve (calibration valve) at the junction of the probe and the heat trace. This allowed for leak checks, sample bias checks and calibration drift checks to be completed, as was discussed in Section 6. These procedures required a calibration or QC gas be directed to the probe and back through the entire sampling system. The difference between the resulting values and the values observed when the gas was passed directly to the instrument is referred to as sample bias. When the bias was above acceptable limits, corrective actions were implemented.

5.1.2 THC Analyzers and Analytical Principles

The THC analyzers used in Method 25A procedures employ a flame ionization detector (FID) to quantify the quantity of THC. As the flue gas enters the detection chamber, the hydrocarbons are combusted in a hydrogen flame. The ions and electrons formed in the flame enter an electron gap, decrease the gas resistance, and permit a flow in an electric circuit. The resulting current is proportional to the instantaneous concentration of the total hydrocarbons. These analyzers are not selective between species; however, different hydrocarbon species respond differently in the FID. Straight chain hydrocarbons (alkanes), alkenes, and aromatics respond in proportion to the number of carbons atoms in the molecule. For example, 100 ppmv propane (C_3H_8) responds approximately the same as 300 ppm methane (CH_4). When measuring THC of these type of compounds, there are no substantial inaccuracies in reporting THC as ppmv as methane. However, oxygenated compounds such as ethanol (CH_3CH_2OH) and

acetaldehyde (CH_3CHO) have a depressed response so that what appears to be 300 ppmv as methane may actually be 1200 ppmv ethanol. The resulting THC concentrations as ppmC were adjusted to ppmv ethanol or ppmv acetaldehyde based on the results of the Method 18 analysis.

5.1.3 Data Acquisition

The signal from the analyzer is typically an analog voltage response (i.e., 0-5 volts). The meter panel on the front of the instrument usually translates the voltage signal to concentration units (i.e., ppmv). However for long term data acquisition, the voltage signals coming from the electrical output leads need to be translated to actual concentration data. The system used to perform this function is known as the data acquisition system or DAS. This process will either be accomplished with the use of a strip chart recorder (SCR) or a computerized system. A SCR is the simplest procedure; howeverc additional man hours were needed to reduce the SCR trace to individual readings (i.e., 1/minute). If a computerized version is used, the analog signal is converted to a digital signal and directed to a computer so that the signal was translated to concentration units and saved to magnetic media. For this test program, a computerized DAS was used and a SCR was used as a back-up system.

5.1.4 Instrument Calibration

Calibrations were performed by passing known concentrations of a hydrocarbon gas standard through the instrument and recording the associated response. A response factor was then calculated and used to adjust sample gas responses to concentration units. Typical calibration calculations were completed as shown in Section 7. The THC instrument was calibrated twice daily. The first calibration was used to determine the response factor, and the second calibration was performed after completing the test runs so that calibration drift can be determined and the test data corrected for drift (if necessary). Calibrations were completed on a two point basis:

zero gas (generally N_2), and a high-range or "span" gas. Methane was used as the calibration gas, and the concentrations were reported as ppmv methane which are the same as ppmv Carbon (ppmC). The gas was certified by the manufacturer guaranteeing the concentration within ±2% accuracy.

Other QC operations were also performed to verify the accuracy of the data produced. These operations included calibration drift and calibration error determinations. Additional procedures such as linearity check, sample bias, leak checks, and gas stratification were also performed. These are further discussed in Section 6.

5.1.5 Example Daily Operating Procedure

The following is a detailed standard operating procedure for calibrating and operating the CEMS:

1. Turn on computer and printer, put printer on-line, and load the DAS program. Be sure that the THC instrument has been on with the FID flame lit for several hours.

2. Synchronize watch with sample location leaders.

3. Turn on strip chart recorders (SCR) and make appropriate notes on charts and in logbook (write down all procedures and observations in logbook and on SCRs as the day progresses).

4. Open all calibration gas cylinders so that they may be introduced to the instruments.

5. Perform daily pre-test leak check on CEMs as discussed in Section 6. If a zero gas is used for this procedure, zero all instruments at this time. Enter these values in the computer calibration routine. Be sure to check and maintain all flows throughout calibration and operation.

6. Introduce the THC span gas.

7. Make adjustments to the THC instrument as required and enter the value into the computer calibration routine.

8. Introduce QC gases to instruments to determine calibration error. Record at least one minute of data for each. If the QC gas response is not within ±5% of the calibration gas valve, the operator will recalibrate the instrument, or perform other corrective actions.

9. Begin sampling routine, with the computer on standby.

10. Start the data acquisition system when signaled by radio that system is in stack.

11. Carefully check all flows and pressures during the operation of the instruments and watch for apparent problems in any of the instruments, such as unusual readings or unreasonable fluctuations.

12. Stop the data acquisition system at the end of the test when signaled.

13. Perform the final calibration (Repeat Steps 5-8) except make no adjustments to the system. This procedure was completed through the calibration valve so that gas is extracted through the entire system.

15. Calculate calibration drift.

All QA/QC procedures are fully explained in Section 6.

5.2 Method 18 for Determining Ethanol and Acetaldehyde Concentrations

The following sections summarizes the sampling and analytical protocols for Method 18 testing procedures targeted for ethanol and acetaldehyde.

5.2.1 Sample Collection

A slip stream of sample gas was taken off the main heat trace line and directed to the GC injection loop as shown in Figure 5-2. Discrete GC injections were made to quantify the gas phase concentration of the two target analytes. This was accomplished by first allowing the gas to vent through the injection loop. Then the injection valve was turned so that the sample gas in the loop is directed into the GC/FID. The number of sample injections in a given testing time frame was determined based on how long it takes for the target compounds to elute from the GC column to the detector. This period of time is known as the retention time (RT). If other compounds are contained in the gas which elute at much longer RT than the target species, they may interfere with the later analyses and the column may have to be periodically cleaned. This is done by raising the oven temperature for a period of time. Cleaning the column decreases the number of GC injections that can be performed during the run time.

5.2.2 Sample Analysis

The U.S. EPA Method 18 analysis is performed using a GC/FID to separate hydrocarbon species present in the exhaust gas stream. The FID employed in the GC works in a similar manner to that discussed in Section 5.1.2. By using a column filled with a sorbent, the various hydrocarbons in a given gas stream were separated so that the instantaneous concentrations measured relate to a specific hydrocarbon. Before sampling the source gas, the GC/FID system was calibrated with standard gas mixtures containing the hydrocarbons of interest. The calibration procedure established both calibration curves (response factors) and retention times for the hydrocarbons. The retention times were used to identify similar compounds in the source samples and the calibration curve was used to quantify the concentrations of the hydrocarbons.

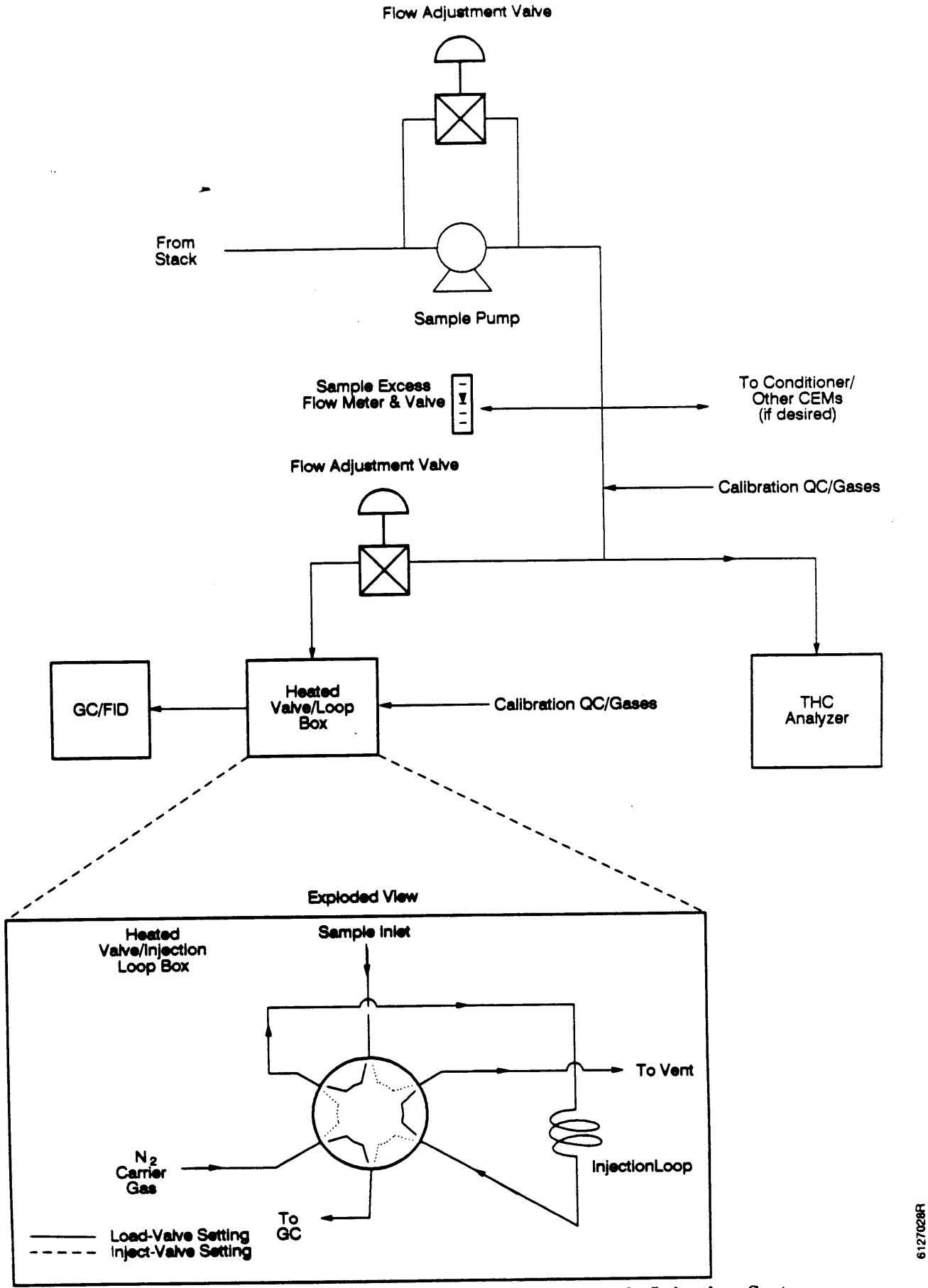


Figure 5-2. General Schematic of Method 18 Sample Injection System

To use Method 18 effectively, standards were prepared to include concentrations over the entire range expected. For ethanol, a suitable collection of standards for bakery emissions concentrations are 0, 200, 800, 2000 and 8000 ppmv ethanol. If stack concentrations are higher than the highest standard, then either higher standards need to be prepared or purchased or the sample needs to be diluted with a gas tight syringe. Levels of acetaldehyde were expected to be less than 100 ppmv, therefore, standards of 0, 20, and 80 ppmv acetaldehyde were used.

The response and retention times of the individual hydrocarbons were recorded on a strip chart recorder. An integrator was used to measure peak areas and compile retention times and area counts. The peaks on the integrator recording were identified from the established retention times for each hydrocarbon of interest and the associated concentrations determined using the calibration curve as a reference.

The column and conditions were as follows:

- Column - 80/120 Carbopack B AW/6.6% Carbowax 20M;
- Carrier Gas - N_2; and
- Temperature - 30°C (isothermal).

5.3 Determination of Volumetric Gas Flow Rates

Determination of gas flow rate incorporates the designation of traverse points by the U.S. EPA Method 1, the measurement of average duct gas velocity by Method 2, the measurement of gas molecular weight by Method 3, and the determination of gas moisture content by Method 4. The following sections discusses those procedures, and the U.S. EPA methods are included in the Appendices.

5.3.1 Method 2 Flow Rate by Pitot Tube

Methods 2 calls for flow determination by measuring the velocity pressure with either an S type pitot or a standard pitot. The following discussion presents the principals of a Method 2 flow determination.

The pitot tube measurements in the ducts were obtained by moving the pitot tube and thermocouple to each of the traverse points designated in Method 1. The velocity pressure and temperature readings at each of those points were recorded. A static duct pressure determined at a single sample point was usually sufficient. This was accomplished by first rotating the pitot tube perpendicular to the flow (as in the cyclonic flow check) until the pressure reading was zero. One leg of the tubing was then disconnected from the manometer and the static pressure was compared against ambient pressure. If the positive tube was left attached to the manometer and the reading was positive, then the overall static was positive. If the negative leg was left attached, and the reading was positive, then the static was negative. The average duct gas velocity and volumetric flow rate was then calculated as shown in Section 7.

5.3.2 Method 3 Molecular Weight Determination

The U.S. EPA Method 3 describes the procedures for obtaining the molecular weight of gas being sampled, which was necessary for the flow calculation. The composite molecular weight of the gas was determined from the relative amounts of individual constituents of the gas stream. In most cases, these principal constituents are oxygen, nitrogen, and carbon dioxide. Some stack gases, however, contain a significant amount of volatile organic or other compounds which can be included in the calculation.

The concentrations of O_2 and CO_2 were determined by a Fyrite analyzer. The molecular weights of such compounds were multiplied by their relative concentrations as shown in Section 7. The products were summed to give the dry

molecular weight of the gas being emitted. The final wet molecular weight calculation required gas moisture content values.

5.3.3 Method 4 Stack Gas Moisture Content

Method 4 is the U.S. EPA method for establishing the moisture content of a stack gas. There are two recognized ways to obtain this moisture content. The first measures the amount of direct condensation of gas moisture in an impinger train. An alternate approximation technique used for stack gases with a temperature lower than 59°C (138°F) employs a wet-bulb/dry-bulb measurement.

Method 4 explains how a sample of the gas is drawn into impingers and condensed using an ice bath. Following the condensation impingers is a desiccant impinger (filled with silica gel) which removes the remaining non-condensed moisture from the gas stream. At the end of the test, the volume of the gas was measured with a dry gas meter and recorded; the impinger weights and silica gel weights were also measured and recorded. These data were used to calculate the percent moisture in the gas stream.

It is important to perform sampling train leak checks at the start and finish of sampling as well as before and after a port change. The method only calls for a post-test leak check but completion of a pre-test leak check indicates that the post-test check was successful as well. To leak check the assembled train, the nozzle end was capped off and a vacuum was pulled in the system of 1 inch Hg higher than the highest measured vacuum. When the system is evacuated, the volume of gas flowing through the system was timed for 60 seconds. The leak rate was required to be less than 4% of the sample rate or 0.02 cfm, whichever was less. After the leak rate was determined, the cap was slowly removed from the nozzle end until the vacuum drops off, and then the pump was turned off.

If the leak rate requirement is not met, the train can be systematically checked by first capping the train at the filter, at the first impinger, etc., until the leak is located and corrected. In the event that a final leak rate is found to be above the minimum acceptable rate upon removal from a port, the run may be rejected.

When the sampling train was ready for operation, the leak rates and sampling stop/start times were recorded on the sampling test log. Other events that occur during sampling, such as pitot cleaning, thermocouple malfunctions, or any other unusual occurrences, were recorded on the test log.

6.0 QUALITY ASSURANCE/QUALITY CONTROL

Specific Quality Assurance/Quality Control (QA/QC) procedures were completed during the test program to ensure the production of useful and valid data throughout the course of the project.

Section 6.1 presents a summary of the QA program and parameters attained. The definitions of the terminology used in conjunction with QA/QC information is presented in Section 6.2. Section 6.3 presents the QA parameters for Method 25A tests. Section 6.4 presents the QA parameters for the Method 18 analyses. Section 6.5 presents a discussion of the carbon equivalent correction factors as well as a comparison of the two methods.

6.1 QA Summary

The majority of reference method QA acceptance criteria were met during this test program. There were 10 days of testing using two THC monitoring systems (20 system days). Method 25A daily calibration drift did not exceed the criterion of ±3% on nineteen of the twenty system days. The Site 1, Day 1 Method 25A test data exhibited calibration drift of 3.2% and the drift was corrected by assuming linear drift between the initial and final calibration. Method 25A calibration error was determined extensively over the course of the test program. Over 150 calibration error checks were performed during the test program and the majority these checks met the Method 25A criterion of ±5% of the gas concentration. Method 25A sample bias checks, as well as O_2 leak checks, were also completed. The majority of these QA parameters met the acceptance limits.

Extensive Method 18 QA/QC procedures were also followed. Initial and final calibrations were performed. Calibrations for ethanol and acetaldehyde were all completed using from 3 to 5 calibration points. Multi-point calibrations were also

performed on methane for low concentrations on all of the test days (< 900 ppmC). On five of the test days, a single point calibration was used on higher methane values. This was due to the detector "overranging". After checking the methane values determined from a single point calibration against a multi-point calibration curve, no substantial difference was found.

Sample bias checks were also extensively conducted on the Method 18 sampling system. The majority of checks verified acceptable non-biased sampling. However, some bias checks revealed sample bias caused by the loss of heat in the heated tubing adjacent to the GC. These data points were invalid and testing was not continued until the problem was remedied and a successful bias check had been completed.

6.2 Definitions

The overall QA/QC objective was to ensure precision, accuracy, completeness, comparability, and representativeness for each major measurement parameter called for in this test program. The terms used to define the QA/QC objectives are designed as follows:

- Data Quality: The characteristics of a product (measurement data) that bear on its ability to satisfy a given purpose. These characteristics are defined as follows:
  - Precision - A measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. Precision can be expressed in terms of the standard deviation (or the relative standard deviation).
  - Accuracy - The degree of agreement of a measurement (or an average of measurements of the same thing), X, with an accepted reference or true value, T, usually expressed as the difference between two values, X-T, or the difference as a percentage of the reference or true value, 100 (X-T)/T, and

sometimes expressed as a ratio, X/T. Accuracy is a measure of the bias in a system.

- Completeness - A measure of the amount of valid data obtained from a measurement system compared with the amount that was expected to be obtained under prescribed test conditions.

- Comparability - A measure of the confidence with which one data set can be compared with another.

- Representativeness - The degree to which data accurately and precisely represent a characteristic of a population, variations of a parameter at a sampling point, or an environmental condition.

- Quality Control: The overall system of activities whose purpose is to provide a quality product or service: for example, the routine application of procedures for obtaining prescribed standards of performance in the monitoring and measurement process.

- Quality Assurance: A system of activities whose purpose is to provide assurance that the overall quality control is being done effectively. The completion of QA procedures generates indicating parameters that are a measurement of the general quality of the data.

6.3 Method 25A Sampling and Analytical QA Parameters

6.3.1 Calibration Drift

The Method 25A Calibration drift values are given in Table 6-1.

6.3.2 Calibration Error

The calibration error checks are presented in Table 6-2. Table 6-3 presents on-site response THC response to ethanol QC challenges.

Table 6-1

Method 25A Calibration Drift EPA Bakeries (1992)

Site	Day	System 1 Drift (% of Range)		System 2 Drift (% of range)	
		Zero Drift	Span Drift	Zero Drift	Span Drift
1	1	0.04	3.22	0.03	-0.69
1	2	-0.01	-0.01	0.16	0.39
2	1	0.09	-0.13	0.04	-0.2
2	2	ND	-1.34	ND	-2.57
3	1	0.07	0.02	-0.14	-0.61
3	2	ND	-0.06	ND	-0.2
4	1	0.17	-0.08	-0.01	0.16
4	2	0.08	0.04	0.04	-0.47
4	3	0.03	-0.13	0.04	0.14
4	4	-0.09	-0.05	-0.01	-0.24

Note: Full range of analyzer was 0-10,000 ppmC. All calibrations performed with methane.

ND = Not determined

Table 6–2. Method 25A Calibration Error Results.
EPA Bakeries, Site 1 (1992)

Methane QC Gas Conc. (ppmC)	System 1		System 2	
	THC Instrument Response (ppmC)	Calibration Error (%)	THC Instrument Response (ppmC)	Calibration Error (%)
SITE 1 – DAY 1				
2000	2039	2.0	2124	6.2
803	805	0.2	GC DOWN	NA
80.2	81.9	2.1	GC DOWN	NA
199.1	198.4	−0.4	GC DOWN	NA
0	4.3	NA	20.3	NA
0	2.7	NA	12.9	NA
2000	1982	−0.9	1963	−1.9
199.1	199.5	0.2	209.3	5.1
2000	1981	−1.0	2089	4.5
803	804.2	0.1	853.5	6.3
199.1	204.3	2.6	224	12.5
SITE 1 – DAY 2				
2000	2014	0.7	1980	−1.0
803	801	−0.2	807	0.5
199.1	197	−1.1	210	5.5
80.2	77.3	−3.6	89.6	11.7
2000	2003	0.2	1937	−3.2
0	3.7	NA	14	NA
2000	1990	−0.5	1986	−0.7
803	805	0.2	803	0.0
199.1	202	1.5	206	3.5

Table 6–2. Method 25A Calibration Error Results, (cont).
EPA Bakeries, Site 2 (1992)

Methane QC Gas Conc. (ppmC)	System 1		System 2	
	THC Instrument Response (ppmC)	Calibration Error (%)	THC Instrument Response (ppmC)	Calibration Error (%)
SITE 2 – DAY 1				
1490	1512.6	1.5	1514.2	1.6
798	812.9	1.9	814.2	2.0
199.1	213.6	7.3	217.6	9.3
3980	3979.6	−0.0	4013.4	0.8
199.1	215.9	8.4	204.9	2.9
798	807.6	1.2	748.6	−6.2
1490	1496.5	0.4	1436.1	−3.6
3980	3931.3	−1.2	3752.8	−5.7
1490	1493.1	0.2	1515.3	1.7
80.2	90.9	13.3	92.5	15.3
80.2	89.7	11.8	87.5	9.1
80.2	89	11.0	88.5	10.3
0	11.1	NA	1.5	NA
80.2	90	12.2	86.8	8.2
798	809.7	1.5	772.4	−3.2
199.1	212	6.5	217.9	9.4
1490	1505.1	1.0	1524.3	2.3
3980	3966.9	−0.3	3953.9	−0.7
0	9.2	NA	4.1	NA
SITE 2 – DAY 2				
199.1	209.3	5.1	206.3	3.6
798	782.6	−1.9	801.2	0.4
1490	1467.5	−1.5	1488.9	−0.1
2000	2041.4	2.1	1936.4	−3.2
2000	2099.5	5.0	1937.6	−3.1
3980	3924	−1.4	3836.6	−3.6
80.2	97.7	21.8	86.8	8.2
199.1	159.4	−19.9	102	−48.8
798	813.2	1.9	754.8	−5.4
1490	1481.1	−0.6	1428.9	−4.1
2000	2008	0.4	2031	1.6
3980	3846	−3.4	3723	−6.5

Table 6–2. Method 25A Calibration Error Results, (cont).
EPA Bakeries, Site 3 (1992)

Methane QC Gas Conc. (ppmC)	System 1		System 2	
	THC Instrument Response (ppmC)	Calibration Error (%)	THC Instrument Response (ppmC)	Calibration Error (%)
SITE 3 – DAY 1				
798	817	2.4	769.7	–3.5
1490	1490	0.0	1390	–6.7
0	1.9	NA	3.4	NA
1490	1490.3	0.0	1419	–4.8
1490	1491.5	0.1	1429.2	–4.1
2000	2030.7	1.5	2071.6	3.6
0	7.1	NA	–14.1	NA
SITE 3 – DAY 2				
0	1.16	NA	–1.5	NA
80.2	77.7	–3.1	68.1	–15.1
199.1	198	–0.6	183	–8.1
80.2	75.3	–6.1	82.5	2.9
199.1	198.4	–0.4	188.4	–5.4
2000	2023	1.2	1909	–4.6
2030	2011	–0.9	1944	–4.2
798	801.5	0.4	783.2	–1.9
3960	3948	–0.3	3849	–2.8
80.2	77.2	–3.7	81.5	1.6
199.1	197.5	–0.8	189.7	–4.7
798	798	0.0	789.4	–1.1
2000	2016	0.8	1874	–6.3
3960	3945	–0.4	3847.2	–2.8
0	–1.97	NA	23.8	NA
1490	1484.5	–0.4	1518.8	1.9

Table 6–2. Method 25A Calibration Error Results, (cont).
EPA Bakeries, Site 3 (1992)

Methane QC Gas Conc. (ppmC)	System 1 THC Instrument Response (ppmC)	System 1 Calibration Error (%)	System 2 THC Instrument Response (ppmC)	System 2 Calibration Error (%)
SITE 4 – DAY 1				
3960	3964	0.1	3966	0.2
80.2	72.9	−9.1	64.4	−19.7
199.1	180.7	−9.2	179.9	−9.6
80.2	60.1	−25.1	60	−25.2
0	−21.8	NA	−6.6	NA
798	810.2	1.5	801.9	0.5
1490	1507.4	1.2	1504.8	1.0
2000	2036	1.8	1939	−3.1
SITE 4 – DAY 2				
3960	3954	−0.2	3960.4	0.0
1490	1506.7	1.1	1506.1	1.1
0	2.1	NA	5.1	NA
80.2	84.5	5.4	75.2	−6.2
199.1	207	4.0	192.6	−3.3
798	804.9	0.9	804.8	0.9
1490	1499	0.6	1509	1.3
2000	2030.2	1.5	1943.2	−2.8
3960	3938	−0.6	3981	0.5
0	8.3	NA	4.05	NA
3960	3964	0.1	3912	−1.2
200	201.6	0.8	192.2	−3.9
200	205.1	2.5	194.3	−2.8
80.2	83.8	4.5	82.9	3.4

Table 6–2. Method 25A Calibration Error Results, (cont).
EPA Bakeries, Site 3 (1992)

Methane QC Gas Conc. (ppmC)	System 1		System 2	
	THC Instrument Response (ppmC)	Calibration Error (%)	THC Instrument Response (ppmC)	Calibration Error (%)
SITE 4 – DAY 3				
3960	3963	0.1	3958	−0.1
3960	3949	−0.3	3873	−2.2
0	−0.7	NA	−0.3	NA
3960	3954	−0.2	3941	−0.5
0	14.5	NA	−0.2	NA
3960	3936.5	−0.6	3930.6	−0.7
0	−0.96	NA	−2.7	NA
3960	3967.2	0.2	3988.9	0.7
199.1	202	1.5	189.3	−4.9
0	2.7	NA	3.8	NA
3960	3947	−0.3	3974	0.4
3960	3964	0.1	3969	0.2
3960	3948	−0.3	3990	0.8
798	796.5	−0.2	808.9	1.4
1490	1486.6	−0.2	1516.6	1.8
2030	2017.3	−0.6	2019.1	−0.5
SITE 4 – DAY 4				
199.1	202	1.5	187.7	−5.7
798	803	0.6	799.7	0.2
2030	2034.8	0.2	2032.8	0.1
80.2	84.4	5.2	67.6	−15.7
0	0.6	NA	−10.8	NA
0	−3.9	NA	−4.6	NA
199.1	200.2	0.6	187.4	−5.9
200	206.8	3.4	191.7	−4.2
2030	2034.6	0.2	2047.5	0.9
0	5.3	NA	−0.8	NA
199.1	199.6	0.3	193.7	−2.7
80.2	766	855.1	76.3	−4.9
0	−2.4	NA	−0.9	NA
80.2	77.8	−3.0	75.5	−5.9
199.1	196	−1.6	183.8	−7.7
798	793.2	−0.6	774.6	−2.9
80.2	83.5	4.1	75.1	−6.4
199.1	202.6	1.8	187.1	−6.0
798	796	−0.3	794.9	−0.4

Table 6-3. On-Site Ethanol QC Challenges to the Method 25A THC Monitor EPA Bakeries (1992)

Site	Test Day	Ethanol QC Gas Conc. (ppmC)	System 1		System 2	
			THC Instrument Response (ppmC)	Carbon Equivalent Correction Factor	THC Instrument Response (ppmC)	Carbon Equivalent Correction Factor
1	1	200	267.5	1.34	238.4	1.19
1	1	200	275.5	1.38	280.5	1.40
1	2	10000	11862	1.19	13569	1.36
1	2	2000	2852	1.43	2948	1.47
1	2	2000	2421	1.21	2731	1.37
1	2	200	272	1.36	274	1.37
			AVG	1.32	AVG	1.36
2	1	200	305.9	1.53	295.5	1.48
2	1	200	310.6	1.55	259.9	1.30
			AVG	1.54	AVG	1.39
3	1	200	320	1.60	283	1.42
3	1	200	302.4	1.51	277	1.39
3	1	498	763.2	1.53	720	1.45
3	1	498	759.6	1.53	694.9	1.40
3	1	498	756.6	1.52	756.6	1.52
3	2	200	307	1.54	286.2	1.43
3	2	200	300.1	1.50	316	1.58
3	2	498	755.5	1.52	765.7	1.54
			AVG	1.53	AVG	1.46
4	1	200	313.5	1.57	299.1	1.50
4	3	200	309.1	1.55	307.6	1.54
4	3	200	313.4	1.57	306.3	1.53
4	3	200	300	1.50	302	1.51
4	4	200	304.6	1.52	307.9	1.54
4	4	200	312.8	1.56	304.1	1.52
4	4	200	297.8	1.49	298.9	1.49
4	4	200	296.8	1.48	304.4	1.52
4	4	200	308.4	1.54	297.2	1.49
4	4	200	DOWN		300.2	1.50
			AVG	1.53	AVG	1.51

6.4 Method 18 QA Parameters

All calibration data from the Method 18 analyses is included in the Appendices. Both an initial and final calibration were performed on each day. Excessive drift was not found during any of the test days.

6.4.1 Sample Bias

Table 6-4 presents the Method 18 sample bias checks for Sites 2-4. The Site 1 bias check results are included in the appendices.

Table 6-4. Method 18 Sample Bias Checks
EPA Bakeries (1992)

INJ. NO	Site/Day	Oven Location	Stack/ System Location	GAS CONC.(ppm)	GC ANALYTICAL RESULT	(%) DIFF	COMMENTS
190	4/1		Rack	80.2 METHANE	97.4	21	
191	4/1		Table	80.2 METHANE	84.7	5.6	
192	4/1		Rack	199.1 METHANE	200.5	0.7	
193	4/1		Table	199.1 METHANE	201.2	1	
194	4/1		Rack	80.2 METHANE	80	−0.2	
195	4/1		Rack	80.2 METHANE	78.1	−2.6	
196	4/1		Rack	80.2 METHANE	76.1	−5.1	
208	4/1		Rack	798 METHANE	804	0.8	SINGLE PT RUN 284 (6/30/92)
209	4/1		Table	798 METHANE	810	1.5	SINGLE PT RUN 284 (6/30/92)
210	4/1		Rack	1490 METHANE	1502	0.8	SINGLE PT RUN 286 (6/30/92)
211	4/1		Table	1490 METHANE	1514	1.6	SINGLE PT RUN 286 (6/30/92)
212	4/1		Rack	2000 METHANE	2040	2	SINGLE PT RUN 287 6/30/92)
	4/1						
213	4/1		Table	2000 METHANE	2003	0.1	SINGLE PT RUN 287 6/30/92)
233	4/1		Rack	199.1 METHANE	196.3	−1.4	SINGLE PT RUN 288
234	4/1		Table	199.1 METHANE	194	−2.6	SINGLE PT RUN 288
235	4/1		Table	200 ETHANOL	207	3.5	
255	4/2		Rack	3980 METHANE	3898	−1.6	
256	4/2		Table	3980 METHANE	4026	1.2	
257	4/2		Rack	1490 METHANE	1499	0.6	
258	4/2		Table	1490 METHANE	1540	3.4	
269	4/2		Table	80.2 METHANE	64.9	−19	RUN ANOTHER CHECK AT SEVERAL LEVELS
270	4/2		Rack	199.1 METHANE	194.8	−2.2	
271	4/2		Table	199.1 METHANE	197.3	−0.9	
272	4/2		Table	798 METHANE	788	−1.2	SINGLE PT RUN #284
273	4/2		Rack	798 METHANE	797	−0.1	SINGLE PT RUN #284
274	4/2		Table	1490 METHANE	1515	1.7	SINGLE PT RUN #286
275	4/2		Rack	1490 METHANE	1534	3	SINGLE PT RUN #286
276	4/2		Table	2000 METHANE	2037	1.9	SINGLE PT RUN # 287
277	4/2		Rack	2000 METHANE	2014	0.7	SINGLE PT RUN # 287
298	4/2		Table	200 ETHANOL	212	6	

Table 6-4. Method 18 Sample Bias Checks (Cont)
EPA Bakeries (1992)

INJ. NO	Site/Day	Oven Location	Stack/ System Location	GAS CONC.(ppm)	GC ANALYTICAL RESULT	(%) DIFF	COMMENTS
27	2/1		Front	1490 METHANE	14.89	0.1	S.P.,COMPARISON TO SYRINGE INJECTION RUN 28
41	2/1			N2	485.121	NA	SMALL BACKGROUND < 15ppm
45	2/1	Bun	Rear	80.2 METHANE	77	−3.9	USED USED FINAL METHANE CAL.
46	2/1	Bun	Rear	80.2 METHANE	78.8	−1.6	
47	2/1	Bun	Front [a]	80.2 METHANE	43.2	−46	PROBLEM/CHECK REPLACE
48	2/1	Bun	Front [a]	80.2 METHANE	56.3	−30	PROBLEM/CHECK, RERUN/REPLACE
49	2/1	Bun	Front [a]	80.2 METHANE	77	−3.9	BETTER/CHECK/REPLACE
50	2/1	Bun	Front [a]	80.2 METHANE	78.8	−1.7	BETTER/CHECK/REPLACE
51	2/1		b		78.7	−1.9	REPLACEMENT
52	2/1		b		78.8	−1.7	REPLACEMENT O.K.
68	2/1		Rear	80.2 METHANE	70.6	−12	
70	2/1		Front	798 METHANE	771	−3.4	SINGLE PT. RUN #26
71	2/1		Rear	199.1 METHANE	189	−5	
72	2/1		Front	199.1 METHANE	188	−5.5	
73	2/1		Front	200 ETHANOL	204	2	
74	2/1		Rear	200 ETHANOL	209	4.5	
122	2/2		Front	80.2 METHANE	77.8	−2.9	
123	2/2		Front	80.2 METHANE	78.9	−1.6	
116	2/2		Front	2000 METHANE	1896	−5.2	SINGLE PT, CAL. UAING RUN 152
130	2/2		Front	798 METHANE	777	−2.6	SINGLE PT, CAL. USING RUN 151
135	2/2		Front	2000 METHANE	2099	−5	SINGLE PT, RUN 152
136	2/2		Rear	2000 METHANE	2012	−0.6	SINGLE PT
137	2/2		Front	3980 METHANE	3975	−0.1	
131	2/2		Rear	798 METHANE	779	−2.4	SINGLE PT, RUN 151

a Nitta Moore Heat Trace check.
New 1/4 inch H.T. jumper to replace Nitta Moore.

Table 6-4. Method 18 Sample Bias Checks (Cont)
EPA Bakeries (1992)

INJ. NO	Site/Day	Oven Location	Stack/ System Location	GAS CONC.(ppm)	GC ANALYTICAL RESULT	(%) DIFF	COMMENTS
20	3/1	Bun	Burner	798 METHANE	799	0.1	SINGLE PT, RUN#19
21	3/1	Bun	Oven	798 METHANE	776	-2.8	SINGLE PT, RUN #19
26	3/1		Burner	200 ETHANOL	203	1.5	INITIAL CAI
42	3/1		Oven	1490 METHANE	1512	1.5	SINGLE PT, RUN #45
	3/1						
43	3/1		Burner	1490 METHANE	1508	1.2	SINGLE PT, RUN #45
65	3/1		Burner	498 ETHANOL	482	-3.2	
66	3/1		Oven	498 ETHANOL	486	-2.4	
67	3/1			80.2 METHANE	88.6	10.5	
68	3/1			80.2 METHANE	86.7	8.1	
69	3/1			199.1 METHANE	214	7.5	
70	3/1			199.1 METHANE	213	7	
104	3/2		Burner	80.2METHANE	73.1	-8.9	
105	3/2		Oven	80.2 METHANE	82.6	3	
106	3/2		Burner	199.1 METHANE	168	-15.6	RERUN
107	3/2		Burner	199.1 METHANE	196	-1.5	O.K.
108	3/2		Oven	199.1 METHANE	205	3	
124	3/2		Burner	80.2 METHANE	80.6	0.5	
125	3/2		Oven	199.1 METHANE	198	-0.5	
126	3/2		Burner	199.1 METHANE	199	0	
147	3/2		Burner	80.2 METHANE	89.9	12.1	PEAK WIDTH SUSPECT
148	3/2		Oven	80.2 METHANE	76.3	-4.9	
149	3/2		Burner	199.1 METHANE	201	1	
150	3/2		Oven	199.1 METHANE	201	1	
151	3/2		Burner	798 METHANE	800	0.2	SINGLE PT RUN #158
153	3/2		Burner	798 METHANE	705	-11.6	RUN MIOMER LEVELS
154	3/2		Burner	2000 METHANE	2027	1.3	SINGLE PT RUN #159
155	3/2		Oven	2000 METHANE	2027	1.3	SINGLE PT RUN #159
156	3/2		Burner	3960 METHANE	3978	0.4	SINGLE PT RUN #160
157	3/2		Oven	3960 METHANE	3973	0.3	SINGLE PT RUN #160
161	3/2		Burner	200 ETHANOL	204	2	
162	3/2		Oven	498 ETHANOL	511	2.6	RERUN
163	3/2		Burner	82.5 ACETALDEHYDE	81.6	-1.1	
164	3/2		Oven	82.5 ACETALDEHYDE	79.3	-3.9	

Table 6-4. Method 18 Sample Bias Checks (Cont)
EPA Bakeries (1992)

INJ. NO	Site/Day	Oven Location	Stack/ System Location	GAS CONC.(ppm)	GC ANALYTICAL RESULT	(%) DIFF	COMMENTS
391	4/4		Table	200 ETHANOL	152	−24	
398	4/4		Table	200 ETHANOL	175	−13	
419	4/4		Table	200 ETHANOL	181	−9.5	
421	4/4		Rack	80.2 METHANOL	82.7	3.1	
422	4/4		Table	80.2 METHANE	82.3	2.6	
423	4/4		Rack	199.1 METHANE	199.3	0.1	

7.0 DATA REDUCTION PROCEDURES

The following section details the calculations used for the U.S. EPA Bakeries test program.

7.1 Emission Calculations

The objective of the U.S. EPA Bakeries test program was to determine emissions of Total VOC as well as emissions of two of the primary VOC constituents, namely ethanol and acetaldehyde. The emission calculations were done using several methods. All rates are in units of lbs/hr.

7.1.1 VOC Emissions

Emission rates of VOC as ethanol were calculated by multiplying the average VOC as ethanol concentration by the stack gas flow rate as follows:

$$\overset{o}{VOC}_{ETOH} = [\overline{VOC_{ETOH}}] \times Q_a \times \left(\frac{P_s}{T_s \times R \times 10^6}\right)$$

Where:

Q_a = Volumetric flow of stack gas (acf/hr)

P_s = Absolute stack Pressure (in Hg)

T_s = Stack Gas Temperature (°R)

R = Universal Gas Constant (21.85 in Hg-cf/lb-mole-°R)

7.1.2 Ethanol and Acetaldehyde Emissions

Ethanol and acetaldehyde emissions were calculated by multiplying the average concentration by the stack gas flow rates. Average concentrations were determined as shown in Section 7.2.2 through 7.2.5. Emission rates were calculated as follows:

$$\overset{o}{ETOH} = [\overline{ETOH}] \times Q_s \times \left(\frac{P_s}{T_s \times R \times 10^6}\right)$$

$$\overset{o}{AA} = [\overline{AA}] \times Q_s \times \left(\frac{P_s}{T_s \times R \times 10^6}\right)$$

7.2 Average VOC Concentration Calculations

The calculations used for determining concentrations are given in the following section.

7.2.1 Average VOC as Ethanol Concentration

The average VOC as ethanol concentration (ppmV as ethanol) was calculated as follows:

$$[\overline{VOC}]_{ETOH} = \frac{[\overline{NMHC}]}{1.42}$$

where:

1.42 = Ethanol Carbon Equivalent Correction Factor (i.e., 10 ppmv ethanol = 14 ppmC THC)

The average non-methane hydrocarbon concentration (ppmC/wet) was calculated as follows:

$$[\overline{NMHC}] = \left(1 - \left[\frac{\overline{CH_4}}{THC}\right]\right) \times [\overline{THC}]$$

The average CH_4 to THC ratios (dimensionless) were calculated as follows:

$$\left[\frac{\overline{CH_4}}{THC}\right] = \frac{\sum_{i=1}^{N}\left(\frac{[CH_4]_i}{[THC]_i}\right)}{N}$$

where:

N = Number of GC injections during test period

$[CH_4]_i$ = CH_4 concentration at the time of the GC injection (ppmC/wet)

$[THC]_i$ = THC concentration at the time of the GC injection (ppmC/wet)

The average THC concentration (ppmC/wet) was calculated as follows:

$$[\overline{THC}] = \frac{\sum_{i=1}^{n}[THC]_i}{n}$$

where:

n = Number of THC readings during the test period

7.2.2 Average Ethanol Concentration

The average ethanol concentration (ppmV/wet) using both the Method 18 ethanol and Method 25A THC results was calculated as follows:

$$[\overline{ETOH}]_{THC} = \left[\frac{\overline{ETOH}}{\overline{THC}}\right] \times [\overline{THC}]$$

The average ethanol-to-THC ratios (ppmV/ppmC) were calculated as follows:

$$\left[\frac{\overline{ETOH}}{\overline{THC}}\right] = \frac{\sum_{i=1}^{N}\left(\frac{[ETOH]_i}{[THC]_i}\right)}{N}$$

where:

$[ETOH]_i$ = Ethanol Concentration from GC analysis (ppmv/wet)

N = Number of GC injections

7.2.3 Average Ethanol Concentration By GC Only

The average ethanol concentrations (ppmV/wet) determined from the Method 18 analyses were calculated as follows:

$$[\overline{ETOH}]_{GC} = \frac{\sum_{i=1}^{N} [ETOH]_i}{N}$$

7.2.4 Acetaldehyde Concentration By GC and THC

The average acetaldehyde concentration (ppmV/wet) determined using both the Method 18 acetaldehyde and Method 25A THC results was calculated as follows:

$$[\overline{AA}]_{THC} = \left[\frac{\overline{AA}}{THC}\right] \times \overline{[THC]}$$

The average acetaldehyde to THC ratios (ppmV/ppmC) were calculated as follows:

$$\left[\frac{\overline{AA}}{THC}\right] = \frac{\sum_{i=1}^{N} \left(\frac{[AA]_i}{[THC]_i}\right)}{N}$$

7.2.5 Average Acetaldehyde Concentration By GC Only

The average acetaldehyde concentration (ppmV/wet) determined from the Method 18 analyses was calculated as follows:

$$[\overline{AA}]_{GC} = \frac{\sum_{i=1}^{N} [AA]_i}{N}$$

7.2.6 Comparison Of GC And THC Results

The comparison of the corrected sum of ethanol, acetaldehyde, and methane Method 18 concentrations to the THC concentration was determined as follows:

$$\left(\frac{\overline{GC}}{THC}\right) = \frac{\sum_{i=1}^{N} \frac{GC_i}{THC_i}}{N} \times 100$$

where:

THC_i = THC concentrations determined from the Method 25A monitor at the same time as the GC injection (ppmC).

$$GC_i = \left(\frac{[ETOH]_i}{1.42} + \frac{[AA]_i}{1.23} + [CH_4]_i\right)$$

where:

$[ETOH]_i$ = Ethanol concentration determined from a single GC analysis (ppmv/wet)

$[AA]_i$ = Acetaldehyde concentration determined from a single GC analysis (ppmv/wet)

$[CH_4]_i$ = Methane concentration determined from a single GC analysis (ppmv/wet)

7.3 Method 25A Calculations

This section briefly summarizes calculations used for the Method 25A analysis. The computer controlled data acquisition system scanned each channel approximately 1800 times per minute and stored periodic averages on disk and hard copy. The averaging computer period varied throughout the test program ranging from 10 seconds to 1 minute. Pre-test calibration, post-test calibration drift checks, and calibration error checks were saved on disk. Instrument drift was evaluated after the post-test calibration with an acceptable criterion of ±3. The computer DAS reported THC concentrations calculated as follows:

$$C_{sample} = RSP_{sample} \times RFAC + C_{rsp=0}$$

where:

C_{sample} = Observed concentration of sample gas (ppmv or %v, dry)

RSP_{sample} = Observed instrument sample voltage response (volts)

$C_{rsp=0}$ = Calculated concentration corresponding to an instrument response of 0 volts (Y intercept)

RFAC = Calibration response factor (slope)

$$RFAC = \frac{(SPAN - ZERO)}{(RSP_{span} - RSP_{zero})}$$

where:

SPAN = Concentration of high (span) calibration gas (ppmv)

ZERO = Concentration of low (zero) calibration gas (ppmv)

RSP_{span}	=	Observed instrument voltage response to the span calibration gas (volts)
RSP_{zero}	=	Observed instrument voltage response to the zero calibration gas (volts)

Span and zero calibration drifts are calculated as follows:

$$\text{Drift} = \frac{(C_F - C_I)}{FULL\ RANGE} \times 100$$

where:

Drift	=	Span calibration drift (% of Scale)
Full Range	=	Full Range of the Instrument (i.e. 0-500 ppmv)
C_F	=	Observed concentration predicted by the final calibration - (ppmv)
C_I	=	Observed concentration predicted by the initial calibration (ppmv)

Average concentrations of THC were calculated for the test duration of interest.

7.3.1 Method 18 Data Reduction

The concentration of ethanol, acetaldehyde, methane and ethane in the stack gas was determined directly as parts per million by volume (ppmv) on a wet basis. An electronic integrator would convert the GC electrical peak signals to a peak area value. A linear regression was completed using calibration gas concentration versus peak area response. Sample responses (peak areas) were then used in the calibration regression to determine the respective concentration.

7.3.2 Manual Gas Sampling Methods

Calculations for determining flow rate, moisture content, and gas molecular weight are described in Figures 7-1 and 7-2.

RADIAN SOURCE TEST
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DEFINITION OF TERMS

Parameter	Units	Definition
t	min.	Total Sampling Time
D_n	in.	Sampling Nozzle Diameter
V_m	ft^3	Absolute Volume of Gas Sample Measured by DGM (uncorrected)
M_w	g	Total Mass of Water Collected
M_p	g	Total Mass of Particulate Collected
P_m	in. Hg	Absolute Meter Pressure
ΔH	in. H_2O	Average Static Pressure of DGM
T_m	°F	Average Temperature of DGM
P_{bar}	in. Hg	Barometric Pressure
$\%CO_2$	% vol-dry	Carbon Dioxide Content of Flue Gas
$\%O_2$	% vol-dry	Oxygen Content of Flue Gas
$\%N_2$	% vol-dry	Nitrogen Content of Flue Gas (by difference)
A_s	ft^3	Cross-sectional Area of Stack (Duct)
T_s	°F	Temperature of Stack
P_s	in. Hg	Absolute Stack Gas Pressure
Static	in. H_2O	Stack Static Pressure
$V_{m(std)}$	dscf	Volume of Gas Sampled at Standard, Dry Conditions[a]
V_w	scf	Volume of Water Vapor in Gas Sample, Std

Figure 7-1. Definition of Terms for Method 1-4 Calculations

RADIAN SOURCE TEST
EPA METHODS
DEFINITION OF TERMS
(Continued)

Parameter	Units	Definition
B_{ws}		Fraction of Water Vapor in Stack Gas
M_d		Fraction by Volume of Dry Gas in Gas Sample ($1-B_{ws}$)
MW_d	lb/lb mole	Molecular Weight of Dry Stack Gas, Dry Basis
MW_s	lb/lb mole	Molecular Weight of Stack Gas, Wet Basis
C_p		Pitot Coefficient (typically 0.84)
C_s	grains/ft^3	Concentration of Particulate in Flue Gas
E	lb/hr	Emission Rate of Particulate
Q_{sd}	dry, ft^3/min.	Average Stack Dry Volumetric Flow Rate
V_s	ft/sec	Velocity of Stack Gas
Y		Test Meter Calibration Coefficient
ΔP	in. H_2O	Stack Gas Velocity Pressure

Figure 7-1. Continued

RADIAN SOURCE TEST
EPA METHOD 2 - 5
SAMPLE CALCULATION

1) Volume of dry gas sampled at standard conditions (68°F, 29.92 in. Hg):

$$V_{m(std)} = \frac{Y \times V_m \times 528 \times [P_{bar} + (\Delta H/13.6)]}{29.92 \times (T_m + 460)}$$

2) Volume of water vapor at standard conditions:

$$V_w = \frac{0.04715\,ft^3}{g \times M_w}$$

3) Fractional moisutre content in stack gas:

$$B_{ws} = \frac{V_w}{V_{m(std)} + V_w}$$

4) Mole fraction of dry stack gas:

$$M_d = 1 - B_{ws}$$

5) Absolute stack gas pressure:

$$P_s = P_{bar} + \frac{Static}{13.6}$$

Figure 7-2. Example of Method 1-4 Calculations

6) Average molecular weight of dry stack gas:

$$\text{Dry: } MW_d = (0.32 \times \%O_2) + (0.44 \times \%CO_2) + [0.28 \times (100 - (\%O_2 + \%CO_2))]$$

7) Stack gas velocity at stack conditions:

$$V_s = 85.49 \times 0.84 \times \sqrt{\Delta P} \times \sqrt{\frac{T_s + 460}{P_s \times MW_s}}$$

8) Average stack gas volumetric flow at dry, standard conditions:

$$Q_{sd} = V_s \times A_s \times M_d \times \frac{528 \times P_m}{T_s \times 29.92} \times \frac{60 \text{ sec}}{\text{min}}$$

Figure 7-2. Continued